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SOVIET SCIENCE & TECHNOLOGY

Science and the Soviet System

Leopold Labedz
Mark Adams
David Joravsky
Arthur E. Humphrey
Aron Katsenelinboigen

Policy and Organization

John Turkevich
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Soviet Science and Technology: An Introduction

John R. Thomas and U. M. Kruse-Vaucienne

I. Current Assessment of Soviet Science

USING the papers in the two volumes of *Survey* (Nos. 102 & 103) as a basis, this introduction is intended to provide an overall assessment of current Soviet science policy and organizations, and of the prospects for the participation of Soviet scientists in the activities of the international science community. Such participation has currently become an operational question, given the USSR's effort in recent years to obtain Western science and technology through numerous official bilateral agreements and other unofficial contacts. It also summarizes the principal issues involved in the science-technology relationship between the US and the USSR.

The Interaction of Party and Science

Any evaluation of Soviet science must begin by noting what can, in Soviet terminology, be called *osnova osnov* (the basis of basics): the role of the science community in the Soviet system and its relationship to the key segment of the system, the Party.

The Party's continuing objective has been to keep control over Soviet science, along with control over other major groups such as the military, the government bureaucracy and the economic planners and industrial managers. The Party's objective has been furthered by the inability of Soviet science as a whole to play an influential political role because of organizational fragmentation. The Party capitalizes on this fragmentation to the full in order to maintain its dominance over Soviet science, particularly over its most prestigious institution, the USSR Academy of Sciences.

The clearest and most symbolic evidence of the Academy's subservient role and the Soviet Communist Party's authority over the Academy was demonstrated by the postponement of the commemoration of the Russian Academy's 250th Anniversary from 1974 (on its appropriate date) to 1975. The Soviet Academy itself wanted to commemorate the occasion on time but that decision was taken out of its hands by the political authorities, for reasons unrelated to the wishes of the Academy.

In fact, the abrupt and sudden deferral in early May 1974 (just a few weeks in advance) of the long-planned, elaborate ceremonies that month honouring the 250th Anniversary is a symbolic indication of the broader political and organizational problems afflicting Soviet science today. The Soviet postponement was ostensibly due to the pressure of

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increased activity connected with the upcoming elections to the Supreme Soviet, the nominal legislative body of the USSR. But these elections to this less-than-supreme political organ in the USSR were to be held a month later and were, like the 250th Anniversary Ceremonies, also scheduled far in advance as part of the normal peace-time routine of the Soviet system. The elections excuse was soon abandoned and another was unofficially given, viz. the illness of the then President of the Academy, Mstislav Keldysh. While the latter has indeed been sick from time to time, substitutes had acted on his behalf on other occasions and could have done so again.

The foregoing suggests that one had to look elsewhere for a possible answer to the May cancellation: the Soviet regime's concern at the time about allowing hundreds of invited foreign scientists to be exposed to unresolved organizational and substantive issues within the Academy and between the Academy and other elements of the Soviet system (Party and government), and also to be exposed to possible contacts with dissident or alienated Soviet scientists. (A group of Soviet scientists who sought to emigrate from the USSR, declared their intent, in advance of the Academy ceremonies, to hold scientific seminars in Moscow and to invite the participation of foreign scientists; some of the latter would undoubtedly have been contacted during their attendance at the May ceremonies, had these been held as scheduled.)

The avoidance of such contacts may have been the real reason for the cancellation. This can be inferred from the fact that even as the cancellation was made at the central level, i.e. of commemoration activities in Moscow and Leningrad, the Soviet regime announced that such activities would take place as scheduled at internal ceremonies in places outside of Moscow and Leningrad to which no foreign scientists had been invited.

This situation demonstrates continuing Soviet touchiness about contacts between its own and foreign scientists and illustrates one of the limits, among others, on the ability of Soviet scientists to play a normal role in US–Soviet activities and in the international scientific community as a whole.

The Soviet Search for Western Aid

Any assessment of the status of Soviet science and its readiness to assume a normal place in the international scientific community must be done in the context of the current Soviet effort to acquire Western scientific and technological know-how. This effort is designed to make up for the USSR's own deficiencies, arising from internal political constraints and organizational problems, and to fill gaps in the broad scientific and technological spectrum, caused by Soviet over-concentration on military and heavy industry priorities. (The latter has created an unbalanced economic system; for example, the neglect of Soviet consumer and civilian needs results from the fact that nearly 80 per cent

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of Soviet research and development funding is devoted to military or related activities.*)

The current Soviet effort to obtain Western scientific know-how and technology is not new; the USSR did so once before, in the twenties and thirties. But there is a significant qualitative and quantitative difference between then and now. In the earlier period, the Soviets, given the relatively primitive state of their economy, were engaged primarily in borrowing from the West in order to build the basic rudiments of the economy (steel, automobile and agricultural implement plants, electric power dams, etc.). Today, the economy of the USSR is at a more advanced level (even though it still lags behind the West), and its requirements are accordingly greater and more complex: the Soviets cannot simply borrow from the West because in many scientific-technical areas they are seeking solutions to problems on which the West itself has not yet made a breakthrough.

The New Role of Soviet Science

To meet their breakthrough requirements, the Soviet leaders must willy-nilly rely on their own scientific establishment. But here the situation is also different from the twenties and thirties. By contrast with that period, the Soviet scientific community today is a hundredfold larger: the USSR currently has over one million scientists and over five thousand research institutes. Because of its larger size, the Soviet scientific establishment is more difficult to control. More important, the Soviet leadership must rely on its scientists to design the latest weapon technology (most of the Soviet scientists work on military or military-related tasks) and to uphold Soviet prestige abroad. Therefore, the leadership cannot as easily terrorize and maltreat its scientists as Stalin could, and did, with the much smaller scientific cadres in the thirties. Such a Stalinist policy cannot be pursued, that is, if the Soviet scientists are to produce vitally important results, e.g. to keep the USSR in the weapon and prestige race with the US: the current goals of the Soviet leadership. In fact, given these goals, the Soviet scientific establishment can be viewed as one of the four key components in the Soviet elite, along with the Party *apparat*, the governmental bureaucracy and the military. Being such a key group, the Soviet scientists can significantly affect the USSR's decision-making, if not in the positive sense of dictating policy, then in the negative sense of frustrating that policy by the failure to score new scientific breakthroughs and to increase the effectiveness of the Soviet economy by developing better applied technology.

Soviet scientists today have neither the most nor the best incentives, nor the appropriate organization necessary to give life to the leadership's recently proclaimed grandiose plans. Because of this situation, the leadership has been forced to scale down its ambitious production

* See Matthew P. Gallagher and Karl F. Spielmann, Jr, *Soviet Decision-making for Defense: A Critique of US Perspectives on the Arms Race* (New York, NY: Praeger Publisher, 1972), p. 55.

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targets, and has had to face the accompanying political embarrassment and, more important, the tremendous impact on the USSR's long-range plans and goals. Thus, the unfavourable situation has affected the ability of the Soviet Union to provide a visible, attractive alternative to Western capitalism, at a time when the latter, in the Soviet view, should be declining and passing into history. Even worse, the economic failure of the Soviet system to date, partly arising from the inability of Soviet science to give its best, together with other problems plaguing Soviet science (to be noted later), has forced the Soviet leadership to turn to the West. This move has profound implications for the Soviet leaders' efforts to preserve their scientists and others in the system from Western " ideological contamination."

The Problems of Soviet Science

Even a brief look at the organizational problems plaguing Soviet science suggests a prime reason for its low performance except in a few select areas: the USSR today does not have a unified scientific command, as it has in other key areas, e.g. the military. Instead, Soviet science is apportioned among the Soviet Academy of Sciences, the State Committee for Science and Technology (SCST) and some 60 Soviet ministries. Each of these bodies has its own budgets, research personnel and scientific facilities which lead to organizational and jurisdictional problems and duplication of effort. But more important, this fragmentation creates policy problems, affecting the performance of Soviet science and technology as a whole. Thus, the Academy, the oldest of the three bodies, founded under Peter the Great in 1724, has seen its position of monopoly in science eliminated in 1961 by the creation of the State Committee for Coordination of Scientific Research. (In 1965, the latter was transformed into the State Committee for Science and Technology.) The SCST has, in the Academy's view, infringed on its exclusive right to make all science decisions and to deal with foreign scientists. This has led to tensions between the Academy and the State Committee. To make matters worse, the Academy lost a number of its institutes and people, when these were transferred to the jurisdiction of ministries in the mid-sixties in order to work on applied problems as opposed to basic science; the latter was, and continues to be, the main interest of the Academy. This interest was precisely responsible for the transfer noted earlier: in the view of the Soviet political leaders, the Academy was doing little to help with the USSR's most acute economic problem, viz. low industrial production, requiring applied science. But this transfer of institutes and personnel created unhappy scientists who had been trained for and who want to work on basic science problems, and who want to do so in the more prestigious setting of the Academy. Because of this transfer, and the difference in emphasis between basic and applied science, the Academy and the ministries are now frequently at loggerheads with each other.

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At the same time, the State Committee for Science and Technology has also had difficulties with the ministries. The SCST is responsible for introducing scientific and technological innovation into ministry institutes and plants. But the latter have resisted the introduction of SCST-sponsored innovations because, unlike the SCST, the ministries are held operationally responsible for the fulfilment of annual production goals, and yet they receive no dispensation for temporary production shortfalls, which inevitably result from time spent in installing the new machinery and in training the workers to use the new equipment. All of the foregoing problems have created a three-way jurisdictional and substantive tug of war among the SCST, the Academy and the ministries, which is currently affecting both creative scientific effort and production efficiency.

To this list of problems might be added the "normal" strains between the scientific organizations at the All-Union and the Republic levels, e.g. those between the USSR Academy of Sciences, with its headquarters in Moscow, and the Republic Academies in other areas of the Soviet Union. The latter feel the "Muscovites" get the best in personnel, budgets and, particularly important in the East-West context, opportunities for interaction with the Western scientific community in the current *détente* atmosphere. (There are also, of course, strains due not only to interests of the centre in Moscow versus the local interests, but due also to nationality problems; in this context, many national minorities feel that the Great Russians at the USSR Academy are unjustifiably dominating the Soviet scientific effort.)

In addition to the organizational, jurisdictional and production problems noted above, broader political constraints have affected the morale and effectiveness of Soviet science. Many of these constraints have become well known to us in recent years; these include limits on the ability of Soviet scientists to travel abroad, on having contacts with foreigners at home, on maintaining normal communication with their foreign colleagues, etc. Unless these limits are modified, it is justifiable to question the USSR's capability for normal relations with the Western scientific community

The Dilemma of the Political Leadership

The Soviet leadership to date has avoided making the politically unpalatable internal changes, relating to such matters as lifting the limits on travel and information exchange that would "unleash" Soviet scientific creativity and provide the basis for normal relations with Western science. These limits are part of a much larger internal question facing the Soviet leaders, viz. control versus efficiency; they feel that to give the Soviet scientists a greater voice in policy-making and implementation can only be done at the expense of the Party's control of Soviet society.

It is the maintenance of such control that has produced many of the

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problems plaguing Soviet science. (Soviet scientists are second to none; therefore, the problems are not inherent in their abilities but in the constraints which have been placed on them.) To avoid facing up to the problems created by its resolve to maintain control at the expense of efficiency if necessary, the Soviet leadership has turned to the West as a means of obtaining aid in filling the scientific-technological gaps created by Soviet internal constraining policies. But should the Soviet leadership discover that there are limits on how far the Soviet Union can borrow from the West, then it may be forced to face the question of control versus efficiency and to modify some of the constraints such as the current limits on travel and information exchanges. Only then could one speak of the possibilities of more meaningfully involving the Soviet scientific and technological community with that of the West.

II. Three Major Themes

THE discussions in these two volumes clearly show that an understanding of science in any country, and particularly in the USSR, cannot result from a study of science alone. This would give a narrow, sterile view; rather, science should be examined as one of several major components in a social and political system. Such an approach tells one more about both the science and the system.

The term "science," used here as convenient shorthand, is imprecise. The issues include basic and applied science, technology, and their conversion to useful practice. Since this spectrum of science and technology then interacts with industry, the economy, the Party, the military, and the West, perhaps a term like "scientific-technological fabric" might be more appropriate, but it seems too awkward. We use "science" to refer in general to the spectrum from basic science to applied technology, but we specify narrower meanings when appropriate.

The use of "science" as a term which embraces both science and technology is also permissible since this workshop was organized to characterize the interactions between Soviet science and other components of the Soviet system rather than to assess individual disciplines. However, we respond to this objective by taking examples from specific areas of science for illustrative purposes. For example, Adams * traces the political development of biology during the Lysenko affair to demonstrate the survival instinct of the Academy. Humphrey discusses developments in single cell protein production to show that vertical integration of science into large-scale production can be accomplished in the civilian sector.

Ganley stated that reducing tensions between the US and USSR is a major objective of US foreign policy. Both countries seek avenues of interaction which are mutually beneficial and least contentious. Science offers such an opportunity. The acknowledged universality of

* All people mentioned here without further identification are authors of papers in the two volumes or were participants in the workshop discussions.

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science also avoids the impediments of proprietary commercial trade. Science strengthens opportunities for national growth, provides broad avenues for communications, and offers a basis for equality, reciprocity and mutual benefit which are objectives of all US–USSR agreements in science and technology. In addition to the objective benefits of scientific cooperation and the accompanying progressive interdependence, members of the scientific community are generally articulate. Therefore, results of constructive interactions in science can be expected to find their way into the social context of each country through dialogues in the classroom and the research laboratory, and through public statements.

But such cooperation frequently raises questions on both sides, and particularly in the USSR, as to whether comparatively unrestrained interactions in science may not jeopardize national security, compromise ideology, or impair commercial integrity. For example, to quote Parrott:

> Who (in the USSR) is likely to resist the expansion of Western ties? The regime's ideological officials appear to dislike the idea. These officials are charged with protecting the doctrine of the USSR's scientific and economic superiority over capitalism, and heavy reliance on Western technology would make this claim more difficult to defend.

Parrott also examines Soviet receptivity to Western know-how and finds mixed views:

> Since about 1972 the Soviet leadership has judged that the prospective benefits outweigh the anticipated costs, and it has sought greatly increased trade and technical ties with the West. Just how firm the support for this new policy is within the leadership is very difficult to say. A preliminary survey of the speeches of prominent Politburo members shows no evidence of overt opposition to the change. There is, though, a noticeable difference between Brezhnev's vigorous endorsements of "long-term, large-scale economic cooperation" and Suslov's rather neutral allusions to the new policy. . . .

While Parrott's discussion refers to technology, it also relates to basic science. Despite possible reservations by some Soviet leaders, large-scale Soviet efforts to date to obtain Western technology and pick Western scientific brains are the best indicators of Soviet intentions.

For a better understanding of Soviet science and technology and their interaction within the system and with the West, we deal with three major themes: perceptions, opportunities and obstacles, structure and weaknesses.

In Section A we consider how the perceptions which the US and the Soviet Union have of each other substantially influence their respective perspectives and actions. The extent to which we can appreciate these perceptions improves our capacity to interpret developments and to

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extrapolate trends, thus minimizing difficulties already inherent in analysing Soviet affairs.

In Section B on US–USSR interactions in science and technology, we consider these in a tactical way, using the barter paradigm in which the needs of each partner and the ease of potential transactions are assessed. We identify factors which either promote and facilitate transactions or which impede them.

Section C on the structure and weaknesses of Soviet science provides the context for assessing how cultural patterns both account for developments and future trends and diminish the effectiveness of Soviet science.

Common points such as the complex relationship of the Party to science, the inefficient integration of science into technology, the historical mandate of science, the pre-emption of resources by the military, and so on, are deliberately brought up again in a "close-up" of these problems seen from three special angles. They take on new dimensions or substantiate themes discussed in sections A, B and C.

A. Perceptions

Initiatives and responses by the US and USSR depend on how each country perceives the other and how each perceives itself.

We have identified seven explicit elements in US perceptions of the USSR. We also identified seven elements of Soviet self-perception and two elements of Soviet perception of the US.

US Perceptions of the USSR

First and most importantly, we must learn to accept the Soviets and their system as they are rather than as what we would like them to become. As a first step in developing a realistic view of USSR technology, Amann suggests:

> An assumption which pervades much Western writing on the subject is that Soviet problems are deeply rooted, systemic, and almost incapable of solution short of major political and economic reform. To date, there has been no serious attempt to evaluate how far Soviet technological performance in particular sectors can be explained by systemic weaknesses and how far by historical backwardness and deliberate (though, perhaps, misguided) policies and priorities.

From Holliday's summary of the discussion, we note a word of caution about superimposing the generally negative Western view of government intrusion in societal activities on the Soviet structure:

> In contrast, another participant found fault with the typology (of Soviet science) because it tends to project our (Western intellectual) values on Soviet scientists. It is fallacious, he warned, to assume that Soviet scientists relate to political authorities the same way their American counterparts do. He noted, for example,

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> that American intellectuals tend to believe that the less political interference they encounter, the better. Soviet intellectuals, on the other hand, tend to believe that some degree of independence and room for manoeuvre is good, but that " a lot is a disaster."

Similarly, Gustafson, in cautioning against applying Western desiderata to analysing the Soviet system, notes that the Soviets consider the certainty of full employment, even if in reality undynamic and involving underemployment, is on balance preferable to the dynamic but unpredictable boom and bust cycles associated with the capitalist system. Lubrano reminds us that we must judge statistics on Soviet science within the Soviet context.

Secondly, the serious lack of adequate and credible statistical information emerging from the Soviet system adds to our misperceptions. One reason for this seems to be the conscious misrepresentation of data. Thus, Parrott says that pressure for performance leads to falsifying information: " One source of the difficulty is the widespread inclination of specialized subordinates to falsify the information about economic capacities and reserves on which the leadership must base its efforts to evoke high performance." There is always the possibility that the Soviet administration does not wish to release certain categories of statistics or that their political decisions prevent the collection of particular data. To emphasize the inadequacy of Soviet data, Western analysts note that published figures for production are often the goals and not the actual results.

Thirdly, the pervasiveness and rigidity of the Soviet bureaucracy characterizes many spheres of Soviet life. Soviet society seems organically committed to stabilizing its bureaucracy. Not only is the Soviet government itself a huge bureaucracy, but it is overseen by two other large bureaucracies: the Party and the Secret Police (KGB). The bureaucratic phenomenon also afflicts other groups, e.g., the Soviet Academy of Sciences itself operates in a highly bureaucratic fashion. Consequently, any perspective which does not recognize the Soviet bureaucracy and its stifling effect on the system will miss the reality of Soviet life. Labedz speculates on the potential effect of the bureaucracies on each other:

> . . . it is unlikely that *apparatchiki* will be replaced in the near future by technocrats in the Soviet political structure because of the effect of necessities imposed by science and technology on the Soviet system. It is arguable, however, that technocratic and " rationalistic " attitudes may slowly penetrate the mentality of the *apparatchiki.* Whether and to what extent this may happen is a question on an altogether different time scale.

Gustafson, however, notes the high quality of individual Soviet scientists, even though he points out the stifling effect of bureaucracy:

> This is not due to any inferiority in the individual abilities of the Soviet scientists (visiting Americans rate them highly), but to the

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> relative rigidity and inefficiency of their policies and organizational structures for science, which hinder the Soviets in responding to the rapid conceptual and methodological changes taking place in many disciplines.

The Soviets are aware of the hobbling effects of their bureaucracy and are developing schemes for improving its effectiveness in guiding Soviet science. Thus, Zaleski describes the establishment of Scientific Production Associations to improve the integration of Soviet research and development results into production; he also cites the development of other organizational plans designed to improve the effectiveness of the Soviet economy. However, Katsenelinboigen notes that precautions are taken to ensure that any alterations in the bureaucracy will not diminish the Party's power.

In searching for explanations of the poor Soviet technological performance, Amann implies that fundamental causes are elusive. We suspect that whatever strengthens our perception of the role of Soviet bureaucracy should help to unravel the cause and effect relationships:

> The fundamental reason for this is that we do not yet know *why* Soviet technology is on the whole backward. How the Soviet research and development system operates is the major determinant of technological performance, and changes in this major condition, less obvious and much more difficult to assess than selected statistics, could have a decisive impact.

Fourthly, we must recognize the highly subjective approach to the Soviet system characterized by an optimistic or pessimistic perception of its evolution. Is the glass half full or half empty? Inevitably, in any analysis of US–USSR interactions, the hypotheses, the presentation of data, and the conclusions will depend upon how the Western researcher looks at his glass of knowledge. The optimist tends to give more weight to favourable possibilities over the long term, while the pessimist may be affected by the current evidence of Soviet shortcomings. The optimist may see the possibility of deeper and extensive interdependent ties between the US and the USSR, whereas the pessimist may see this as impossible, given his projection of current Soviet behaviour. The optimist is conscious of the step-by-step process by which human interaction evolves, while the pessimist wants the world tuned to his view instantaneously or he gives up prematurely. The optimist knows that American industry is apprehensive about visits to its laboratories; the pessimist is incensed when the Soviets fail to bare all their work upon the first meeting. Perhaps these contrasting attributes are oversimplified or not completely accurate, but the factor of optimism or pessimism in viewing US–Soviet relationships clearly affects the analysts' conclusions and must be taken into account.

Fifthly, we tend to judge the quality of Soviet science in terms of the number of Nobel prizes received—a limited and misleading measure. Gustafson points out that many areas of basic Soviet science are in fact

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held in high regard by foreign peer observers. In this connexion, Graham states that:

> Indeed, it is probably no exaggeration to say that the Academy of Sciences of the USSR is the most important single scientific institution in the world, since in those countries which equal or surpass the Soviet Union in quality of science or overall scientific effort, fundamental research is dispersed throughout a variety of autonomous universities and institutions, both public and private.

Fusfeld, Amann and Hanson conclude that the principal deficiency of the Soviet science and technology organization lies in its inability effectively to apply the results of basic research. Hence, opinion which blames the quality of the USSR's science for the backwardness of its technology is widely off the mark.

Sixthly, we tend to perceive the USSR as a homogeneous monolith, without considering individual differences and structural conflicts within the system. To put it simply, the Soviet leadership appears to many Western Sovietologists to be as fragmented on issues as that in the West, despite the Soviet ideological objective of promoting governmental and societal homogeneity. Parrott calls this to our attention by focusing on the differing views expressed by Brezhnev, Kosygin and Suslov on the state of economic development at home and abroad. Most assuredly, the Soviet scientific community is not monolithic. Indeed, according to Graham, the jurisdictional struggle for power here is clearly evident:

> Some American scientists have spoken about serious competition to the Academy from other Soviet organizations, especially from the State Committee for Science and Technology. Other Western observers have considered it inevitable that Soviet universities would gain in scientific influence at the expense of the Academy, with the result that the organization of Soviet science would become progressively similar to the organization of science in the United States.

Labedz further characterizes deficiencies in the administration of science:

> While the post-Stalin science policy removed some of the obstacles to the pursuit of learning in various disciplines, the dilemmas of pure science versus applied science, of centralization versus decentralization, of governmental pressure to subordinate science to the requirements of the economic plans versus the needs of fundamental scientific research have been as vexing as ever . . .

Seventhly, the structure, the product mix and the growth rates of Soviet industry are different from those in the US. On this point, Amann notes:

> . . . some Soviet industries which have continued to expand rapidly are industries in which the rate of growth has slowed down considerably in other major countries; hence, for example, plastics and

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> man-made fibres have replaced steel and cotton in the USSR much more slowly than elsewhere. . . .

Thus, rampant enthusiasm for a new product in the US may leave the Soviets unexcited; conversely, the Soviets may be enthusiastic for a process which the US considers of little importance.

Soviet Perception of Their Own Science

Seven elements of the Soviet perception of their own science can be identified. The first and undoubtedly the most important element, is the status of science in the USSR. Its role in the Soviet system extends beyond the functional one of providing knowledge and adding to material well-being. It has political, almost religious, functions in at least two aspects: science is regarded as an integral part of communism. Party theoreticians consider that communism will be progressively refined and strengthened by the results and stimuli of science; and, in a related point, science is regarded by the Party leadership as a legitimization of its power. Good science is taken to imply effective Party administration. Both Adams and Rabkin discuss science as providing legitimacy for the leadership.

These points are sharpened if we focus on technology. Productivity of the Soviet economy is taken as a direct indication of the success of communism. But productivity is limited directly by the effectiveness of technology. Growing Soviet recognition of this truism came in Khrushchev's days, when the damage caused by Stalin's terror and arbitrariness was openly acknowledged.

So the Soviets link technology to science, creating a scientific-technological revolution, which is expected to shape the future Soviet working environment and solve social problems. Turkevich quotes Suslov on this point upon the occasion of the Soviet leader's receipt of the Soviet Science Academy's Marx Gold Medal in 1976:

> The contemporary scientific-technological revolution opens before society unseen possibilities in using science for mastering and protecting the forces of nature and solving social problems . . . and at the same time acts as material preparation for communist civilization.

This formulation clearly links science as a magic genie with science as the provider of legitimacy for the Party. While Suslov, in his role as Party secretary and current flag bearer of communist ideology, states the contemporary official Soviet view, Labedz notes that this is not really new since the Tsars also enshrined science in their days.

Secondly, science is intended to contribute to social and economic needs. The Soviet leadership has expressed this concern on various occasions. Labedz points to one such occasion:

> Khrushchev's " de-stalinization " after 1956 removed some of these obstacles. Growing attention was devoted to the problem of tech-

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> nological innovation, and science was elevated to the status of a "productive force" in the new Party Programme at the 22nd Party Congress, with the implication that it would play a more fundamental role as part of "the material basis" and not merely as an aspect of the "superstructure."

Also, the creation in 1961, and increasing power since then, of the State Committee for Science and Technology (SCST) is an important indication of the pressure by Soviet leaders for science to be relevant to the USSR's needs. In fact, the State Committee was set up precisely because of the leadership's dissatisfaction with the Academy in meeting Soviet production needs.

Thirdly, the scientific structure and its programmes are expected to be subservient to national needs. Should the Soviet scientific establishment fail to respond to political pressure, Labedz predicts the outcome: "... when the chips are down (the Soviet scientific establishment will) accommodate itself to the requirements of the system, rather than vice versa." The Soviets seem at once confident but impatient for science to make a critical contribution towards "getting things moving."

Fourthly, science is a deep-seated and stable component of Russian culture, with associated prestige and influence. In contrast to the present anti-intellectual trend in the US, Soviet science enjoys strong support from all levels of society. Also, Soviet science is a clear part of the governmental structure and is incorporated in the official planning process. The fact that many, if not most, of the vocal dissidents are scientists who are protected because they are members of the Soviet science community confirms the *de facto* enshrinement of science. Finally, the creation of numerous science centres, most notably Akademgorodok, outside Novosibirsk, together with a plethora of scientific laboratories, also emphasizes the broad support of science. Graham confirms a continuing and favourable societal view of science: "The commitment of the Soviet government and of Soviet society to the support of fundamental research seems to be firm, and the Academy is the primary beneficiary of that largesse." Most important, as pointed out by Turkevich, the USSR's political commitment to science and technology is symbolized by the fact that most of the 21 members of the ruling Politburo are technologists, as are most of the 60-some members of the Council of Ministers.

Fifthly, science is considered to be a key component in Soviet attainment of military pre-eminence. Holloway argued that because the USSR feels it needs sophisticated weaponry, it must increasingly rely upon science to contribute strategic ideas and options. Further, contrary to the generally uneven and inefficient integration of science and technology into production in the civilian sector, the military sector is structured so as to maximize benefits from scientific results. Holloway

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cautioned us, however, that sizeable Soviet military capabilities cannot be taken as automatic evidence of superior technology.

Sixthly, the linkage between science and technology is not sufficiently developed, possibly accounting for the poor performance of Soviet technology relative to Soviet science. This widely acknowledged weakness of the Soviet system is what Hanson specifically and Amann and Fusfeld indirectly refer to as lack of effective vertical integration, i.e., while Soviet scientific knowledge unquestionably is outstanding, there are barriers to its utilization. This weakness, which is discussed later in more detail, exists in part by conscious choice: political control takes precedence over efficiency. The Soviets clearly recognize this shortcoming and have sought several times to alleviate it by reorganizing their scientific and technical efforts, while at the same time not losing any political status of the Party. Amann identifies four Soviet programmes undertaken to improve the situation, and Zaleski discusses several recent decrees issued by the Party which aim at solving these problems.

Seventhly, there is growing concern and interest in developing a more organized and indeed scientific view of science. This will give the Soviets a more quantitative view of their science and presumably the capacity to improve it as well as its effects. To understand the nature of this development, Gustafson analyses the Soviet view of US science. He argues that the way the Soviets interpret US science reveals a great deal about science in the USSR.

Further, Rabkin describes how the Soviets are developing the discipline of science policy (*naukovedenie*) and comments on its implications. He is especially impressed by the candour with which the Soviets criticize their own science; he attributes this to the widely accepted Soviet assumption that because the scientific establishment needs preferential treatment from the authorities, it also deserves close scrutiny and criticism when warranted. Rabkin notes that the Soviet analysts see restricted communication with scholars abroad as a significant barrier to quick diffusion of information. He speculates on the future of *naukovedenie*, asking whether it will be even more bureaucratized and lose its initial zeal or whether it will eventually provide access to useful and timely information to experts within and outside the USSR. If the latter proves to be the case, then the correction of some Soviet shortcomings may follow.

According to Gustafson, the Soviets have diligently compared the relative value of the US project-grant system with the longer term Soviet funding of large institutes. They seem fully aware that the former is more sensitive to national interests while the latter may lead to insularity or parochialism. Gustafson quotes one Soviet researcher who remarks cynically that

> . . . the excessive generosity with which we are funded sometimes creates conditions which support idle exercises for years, under the

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> umbrella of "unlimited freedom of inquiry." The champions of this freedom passionately exclaim, "Who can deny the possibility that my thesis, which seems unpromising today, may cause a revolution in scientific theory tomorrow!" Then examples are cited from the schoolchild's history of great scientific discoveries. . . .

Gustafson also states that the Soviets seem to be weary of their own incentive system and may be examining the more productive incentive system in the US for some form of adaptation in the USSR.

Soviet Perception of the West

Two ideas seem to dominate the Soviet perception of the US. First, the Soviets consider US achievements as the principal criteria in measuring Soviet success. Efforts to "overtake and surpass the US" are a Soviet objective that dates back to the 1930s. In this context, Parrott suggests that the Soviets find themselves challenged by US progress even more today:

> . . . a 1970 article in *Kommunist* cautioned that "it is extremely dangerous to manifest slowness in using the enormous advantages of socialism over capitalism in the area of the comprehensive and accelerated development of science and technology and the improvement of administration." The implication was that the developed capitalist states had raised a new economic and technological challenge which required that the Soviet leadership respond with major changes of policy.

Hanson underscores the widespread Soviet habit of borrowing from the West but alerts us about possible changes in Soviet strategy:

> At all events, the situation which Soviet policy makers are trying to alter by international transfer is one in which they currently lag behind the West. There is nothing new about it. Russia has been trying to catch up by importing Western technology, as several writers have pointed out, at least since Peter the Great. Many observers, including the present author, believe, however, that the Soviet strategy has changed significantly in recent years.

Hanson considers the Soviet predicament as one of being thrust on a treadmill while simultaneously shooting at a moving target:

> Once it was widely grasped by Soviet managers and planners that catching up with Western technology meant chasing a rapidly moving target over an ever-increasing product range, a shift in policy was almost inevitable.

A second element in the Soviet attitude to the West is their strong desire to be perceived and accepted by the West as technological equals. To attain this goal, the Soviets take advantage of any opportunity to create a favourable global image of their scientific and technical capability. Certainly, the 1975 Apollo-Soyuz collaborative effort fits into

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this scheme. In general, any US–USSR agreements for cooperation in various areas of science aim to further promote the Soviet objective.

B. Opportunities and Obstacles in US-USSR Cooperation

Soviet requirements may be cultural as well as economic, and the two are interdependent. Any US initiative which tends to fulfil these requirements should qualify for USSR concessions relevant to US needs.

To begin with, the US should recognize that it contributes to increasing Soviet needs by setting global trends. Thus, as the US continues its steady advances in technology, the gap between the US and USSR widens even further and therefore defines greater needs by the USSR. Naturally, it is not in the interests of the US to minimize its quest for technological breakthroughs and innovatory approaches. However, as the US continues to function as a yardstick for the USSR by developing more sophisticated products and processes, the gap may never close. Indeed, Hanson, Parrott, and Amann observe that the gap, if anything, is progressively widening. Unwittingly, the West makes the Soviets more dependent, not only by defining the upper parameters of needs but also by provoking the Soviets to come to the West for instant transfusions rather than depending upon their own slower-paced developments. Since, as Fusfeld reveals clearly, the Soviets do not integrate their R & D production and marketing effectively, in many cases they are already behind when the race starts to develop a new product.

The USSR's need for technology from the West is quantitatively estimated by Green and Levine, who assert that Soviet investment into Western technology returns eight to 15 times as much as the same investment into domestic technology. While Hanson questions the magnitude of the return, he acknowledges that the idea is basically correct. Green and Levine further note that 15 per cent of the Soviet growth in the 1968–75 period could be attributed to Western machinery.

Some of the USSR's requirements described specifically below are restatements of characteristics of the Soviet system presented in earlier parts of this study. They are collected and enumerated here as specific guides for US–USSR interactions.

First, the Soviet need associated with the discrepancies between anticipated and actual effectiveness of the communist system seems to be exemplified by the deficiencies in the Soviet technological enterprise. There, the relatively poor performance does not seem to be consistent with either ideological or economic goals. Thus, the Soviets have concluded that they must promote major interaction with the West to make up their deficiencies. The US, in return for a hoped-for relaxation of tension, is trading on the requirement defined by the deficiency of Soviet technology.

On the whole, pure science in the USSR cannot be considered deficient. Graham notes that the USSR Academy of Sciences is the most

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respected single institution in the USSR. Academicians are distributed throughout university and ministry as well as Academy laboratories. Turkevich confirms this and says that the dispersion of Academicians within Soviet institutions gives the Academy power and influence which are unique in any society. If any deficiency in science exists, it would appear, according to Gustafson, to be in its organization and utilization.

It seems that a preoccupation with production goals prevents Soviet enterprises from pressing the science community for a closer and more productive relationship, i.e. the development of new products is frustrated by commitment to existing production of possibly inferior products. As a result, the Soviets turn directly to the West for whole new plants and processes which can be plugged into their production in place of indigenous development. The society is then cheated of incorporating the preliminary trial and error experiences into their technological culture, thereby contributing to the USSR's systemic weakness. However, Zaleski thinks that contributions from the West so far have not produced significant improvement.

Secondly, the Soviets wish to strengthen their scientific base for military developments. Holloway saw the foundation for the military's scientific support in both Soviet and, indirectly, in Western sources: as military equipment becomes more complex, it must rely progressively more on basic science; hence, military needs in science overlap with the domestic sector. Sophisticated military hardware thus, in fact, depends more upon science in general, regardless of its source. The pressure for new techniques and ideas then causes the government to solicit outside sources. One cannot avoid facing the implication that Western science is likely to be incorporated into the Soviet military and that part of the Soviet initiative to establish science exchanges with the US arises from military needs. In this connection the military origins of the State Committee for Science and Technology (SCST) should not be overlooked. Holloway reasoned that:

> Much research of military importance is done in the "civilian" sector, and it seems likely that the State Committee has a role in fostering and directing research of military interest, and in drawing military attention to promising lines of research.

Thirdly, the Soviet goal to achieve international recognition and prestige equal to the West is a definite need. Thus, if the Soviets are partners with the US in scientific exchanges, they are, in the eyes of the world, equal to the US. The Apollo-Soyuz space rendezvous is a case in point and certainly has rendered a perception of equality between the two nations. By consciously developing this prestige image the Soviets can negotiate more effectively with other countries. We conclude that the Soviets will contrive to seek projects which promote the image of equality with the West in both science and technology.

Fourthly, the Soviets seem to require a rationality that avoids risks. The Soviets seem to be more sensitive than Western nations to the em-

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barrassment of failure. Further, in their rigid system and culture, few if any options are open once failure occurs. The natural reaction is to avoid making decisions that can be traced to a single person. Parrott points out that, by obtaining science and technology from the West, they adroitly pass the buck to their leaders who initiated the interactions with the West and, if that is not enough, to the West. This probably accounts for the guarantees required by the Soviets for various licence and turnkey projects. The preoccupation with avoiding risks was neatly summarized by Parrott, who noted that when plant managers were surveyed, they preferred to maximize their own personal security rather than having free market choices.

Fifthly, the Soviet need for hard currency is affecting their negotiating position *vis-à-vis* the West. Although, as Bush emphasizes, they are reluctant to sell their natural resources, their present currency deficit of some $17 billion may require them to reconsider their position. Certainly the situation may force them eventually to limit the number of large turnkey projects in favour of licence agreements with the US. In order to reduce the currency problems, it seems reasonable for the Soviets to want to sell their own products on the world market. However, as noted by Bush, the quality of Soviet goods is rather shoddy, which makes Western countries reluctant to purchase them. At any rate, the currency problems of the USSR give the US an advantage.

The major factor facilitating the US initiatives is the array of Soviet requirements, i.e. there is a clearly defined receptivity. The importance of specific needs varies cyclically and depends on the political climate. Below we examine several of the mechanisms by which transactions can be facilitated.

Organizationally, the US entry into the system of Soviet science and technology is encouraged by the high political connexions which science enjoys in the USSR. The principal entry point for US–USSR technical exchanges, even those related directly to a commercial programme, is the State Committee for Science and Technology (SCST). Its high political connexions provide the necessary contacts throughout the Soviet system. The fact that it has flexibility and direct institutional responsibility for coordinating all Soviet science and technology means that the SCST can place Western organizations in touch with their Soviet counterparts.

Similarly, the Academy of Sciences is operated by a strong, central command. All Academy institutes and Academy activities are connected through a central organization with many of the university and ministry laboratories. It therefore provides a single, efficient mechanism for almost all cooperative ventures in basic science.

The Soviet production ministries and the US private sector are encouraged to establish direct contacts with each other in Article IV of the US–USSR Agreement on Scientific and Technical Cooperation. The focus is on science and technology, but such joint relations

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between " enterprises " of both countries are almost always built around specific commercial plans or production objectives. Thus, many commercial arrangements are expedited by the mechanism of Article IV, often with the active involvement of the SCST.

Another major factor in facilitating cooperation is the cultural predisposition of the Soviet people towards science. It has been held in high esteem both by the Russian people and the Soviet system. Expression of the broad cultural acceptance of science is found in the steadily expanding R & D budgets in the national plan, and in the establishment of science centres such as Akademgorodok, near Novosibirsk. Science support in the USSR will probably be uninterrupted and stable for a reasonably long time to come.

Interestingly, the Soviet military may be another facilitating factor. This is not just because of the need for advanced Western science and technology in military weapons development. Rather, we refer to the fact that the effectiveness of the military in organizing the vertical integration of science with production may be progressively adopted in the civilian sector. Khrushchev, as early as 1962, urged the civilian sector to copy the military approach, according to Parrott.

Finally, there is a clear trend towards improving the incentive system in order to create greater responsiveness to new ideas. The Soviets appear to have concluded that this path, while politically questionable, may nonetheless be pragmatically necessary.

Perhaps the greatest single impediment to interaction between the US and USSR is the fear of risks which prevent personal commitments. This propensity can be traced at least to the Tsars, but seems worsened by the present Soviet system. The overwhelming bureaucracy of Soviet government is perhaps the most visible as well as stultifying expression of this propensity for avoiding personal risks. Several authors make it clear that even the Soviets resent this burden, despite the fact that it is self-inflicted. In addition to the bureaucracy of the planning organizations and the ministries which, in a sense, are the line organizations, the Party has a parallel organization which oversees every aspect of scientific and technical activities. And, as if that is not enough, the KGB exerts influence on the contents of published papers, on foreign trips of Soviet scientists, and on the admission of outside visitors.

This pressure no doubt fosters the excessive emphasis upon central planning, which in itself is immobilizing. If the plan is well enough organized, no one takes risks; and if the planning organization is large enough, no one can be blamed. Further, when errors occur, the system somehow identifies a recalcitrant as an unfortunate scapegoat whose demise somehow absolves the system.

The reality of an entrenched bureaucracy in the Soviet Union impinges upon the West in many ways. For example, in commercial interaction it leads to unrealistic contractual terms, to specifications that cannot be met, to frustrating delays, and to unfulfilled expectations.

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Another serious impediment, as well as a need described above, is the lack of hard currency. Major cooperative commercial ventures that require substantial capital investments, often involving transfers of Western proprietary technology, will be limited by the difficulties the Soviets encounter in developing hard currency reserves. One solution to the hard currency problem occasionally gives rise to its own impediments. Commercial projects are often considered in which the Western investor is to be paid by receiving some amount of gas, oil or metal produced with the investment. There is some Soviet resistance to such arrangements on the grounds that they are giving away a natural resource which is a foundation of their future economy. These obstacles can be dealt with through barter arrangements, but they must be recognized when planning major industrial projects.

Finally, some institutions of the Soviet system are deeply troubled by and may actively oppose interactions with the US. These are principally the Party and the KGB. Concerns for ideological purity as well as compromised security are the nominal reasons. It is reasonable to suspect strong elements of traditional Russian xenophobia to be at work here as well. This causes a careful selection of those people destined to interact directly with the US. The criteria for such selections seems to be political reliability first, and technical competence second, a factor that may impair the quality of the scientific cooperation.

A final obstacle arises from what appears to be the Soviet practice of withholding data. In some cases, no matter how diligently analysts press for information, it is not forthcoming, or when it is available, it is suspect.

C. Structure and Weaknesses of Soviet Science

Elements in the Structure of Soviet Science

The principal institutional features of Soviet science can be summarized as follows:

—Soviet science is connected to the government directly through clearly defined lines of organization.

—The producing elements of Soviet science are the Academy laboratories, ministry laboratories and the universities.

—Science is coordinated within the Soviet Union and with foreign countries by the State Committee for Science and Technology, although Gosplan coordinates some of the domestic planning.

Elements of the structure of Soviet science are described by Turkevich. Graham discusses the structure of the Academy, while Adams shows how it responded to a crisis in the development of biology. Lubrano assesses the professional competence of scientists, while Joravsky interprets their intellectual integrity. Problems of integrating the elements of science with production—vertical integration—are considered by Fusfeld from a pragmatic view, by Humphrey with respect

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to an example of successful vertical integration, and by Amann, Hanson, Parrott, and Labedz in terms of systemic problems.

While these articles deal extensively with the Academy, and reflect concern about the problems of vertical integration, much less is said, in detail or in broad terms, about the structure and operation of the laboratories in the ministries. This area is less well known, and appears to deserve more detailed attention because of its role in vertical integration. Finally, research at the universities is not discussed at length. However, this reflects the fact that Soviet universities do not play the same extensive role in fundamental research as the American universities.

The four critical issues which are significant to understanding the contemporary structure of Soviet science are:

—Extent of the SCST's responsibility for the direction of the Soviet scientific effort.
—Strength of the Academy.
—Improvements in the efficiency of vertical integration.
—Possibility of incorporating the military model for vertical integration into the domestic sector.

These issues are discussed below.

State Committee for Science and Technology

To characterize the role of the State Committee for Science and Technology within the structure of Soviet science, Graham analyses the Committee's impact upon the Academy. Graham, in responding to concerns by Western scientists for the possible decline in the influence of the Academy, states that probably the most substantial encroachment upon the traditional hegemony of the Academy comes from the SCST. Starting with political protocol, the head of the SCST outranks the President of the Academy on the Council of Ministers where they are both members, with the former also being Deputy Premier.

The SCST facilitates and coordinates all aspects of science in the USSR as well as with foreign countries. Graham points out that SCST selects priority projects for the National Plan:

> The State Committee periodically compiles a list of the current 200 to 250 most important scientific-technical problems facing the country and works with the State Planning Committee (*Gosplan*) in seeking their solution.

But the SCST may exert its most decisive influence on the direction of Soviet science by its financial leverage. Acording to Graham, the SCST receives each year 2–3 per cent of the total R & D budget to be distributed wherever it sees the need. This then can act as a persuasive mechanism: one can imagine that such resources, suitably focused and placed, would stimulate research in key elements of science. On the other hand, this capacity of the SCST might be seen as a way of

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getting the laboratories to promote science which is both of high quality and relevant to immediate needs.

The SCST integrates the input from the scientific community through a system of advisory subcommittees and scientific councils which, as Graham points out, gives the SCST the assistance of thousands of Soviet scientists, including most Academicians. The SCST retains the executive authority over these bodies.

If the aphorism " success breeds success " is applicable, the influence of the SCST will grow. One can speculate that the monetary leverage, the institutional flexibility, and network of contacts may prove effective tools for improving the functioning of the entire Soviet science-technology spectrum while at the same time pushing into impotence those organizations which do not comply. Unfortunately, the SCST is also a bureaucracy and may not be able effectively to implement its good intentions of providing productive leadership.

Academy's Strength

The Academy is a pervasive and enduring institution in the Soviet system. Pressures for industrial relevance have been exerted spasmodically throughout its life according to Labedz:

> Soviet science policy has reflected from the beginning some ancient problems in this field. When Peter the Great founded the St. Petersburg Academy of Sciences in 1724, it was given the task not only of carrying out scientific research but also of helping the government to solve practical problems. Its statute made it mandatory for its members to work on projects given to them by various departments of the government. With time these obligations fell into disuse as the academicians tended to pursue knowledge for its own sake. But the First World War and the October Revolution in particular reversed this trend.

After the Academy lost jurisdiction over its applied laboratories in the early 1960s—approximately 40 per cent of the total Academy laboratories at the time, according to Graham—it retained the primary mandate for all fundamental science in the Soviet Union. According to Graham, the incentive for this alteration came from within the Academy:

> The removal of the industrial research institutes from the Academy in the early sixties was not an action that was forced on the Academy, but a reform that was strongly supported by an influential group of Academy members working in the basic sciences, particularly chemistry, physics and mathematics. These scientists wanted to correct what they saw as an exaggerated emphasis on applied research during the Stalinist period.

A cultural subtlety identified by Graham tends to confirm the continued vitality of the Academy:

> Whether one is interested primarily in promoting intellectual

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> quality or defending those areas of relative political autonomy which exist in the Soviet Union, the Academy is a precious institution to the Soviet intelligentsia. This alliance of establishment and non-establishment sentiment . . . is one of the hidden strengths of the Academy.

The Academy exerts a decisive influence also upon the quality and permanence of fundamental science through its influence upon university education. Graham states:

> Many of the academicians and leading researchers in the Academy also have connections with the universities. When they identify bright and promising young students at the university, they often invite them to participate in research in the institutes of the Academy, which, like the universities, have the power to award advanced degrees. The negative side of this process is that the universities have difficulty building up an independent research system of high quality, since the Academy often takes their best students.

The Academy's mandate for fundamental science has been somewhat interfered with by governmental pressure for relevance. However, the extent to which this pressure for relevance is actively realized in laboratory programmes is questioned in the analyses of Gustafson, Adams, and Rabkin. Adams demonstrates how the Academy adroitly dealt with Lysenkoism by simply incorporating the needed biological science into institutes other than those nominally responsible for the subject. Gustafson as well as Rabkin show that mandates given to institutes through budgets are not perceived by the bench scientists; and they can work, bureaucratically insulated, deep in the institutional labyrinth on essentially whatever pleases them.

Graham concludes his analysis by saying that, on balance, the Academy has to date retained its institutional strength, though ultimately this will depend on the activities of the SCST. His tentativeness on this point seems to reflect accurately uncertainties in the community of Sovietologists.

Problems of Vertical Integration

While much has been said by the authors on the weaknesses of vertical integration, little of the interacting institutional elements has been described except in the study by Humphrey, which deals with the development of enriched feed from single cell protein. The discussions of vertical integration have been more related to political and cultural, i.e. systemic, causes. This area is dealt with in this review in the " weaknesses " part of this section and in the section concerning obstacles to interaction.

Interaction of Military Needs with Civilian Science

The Soviet military programme interacts with non-military sciences in several important ways. Holloway examined the commonly accepted

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assumption that the level of military technology in the USSR is higher than that of civilian technology and thus the latter should learn from the former. He ascribed the sophistication of military science and technology to two factors: first, the increasing complexity of military weaponry requires a more refined scientific input; secondly, the scientific community in turn is proposing weapons which were not imagined by the military; he summarized the interaction of science and the military as follows.

> First, while in relation to production science is becoming a direct productive force, in terms of military affairs it is gradually becoming their most important element; modern weapons cannot be created without the application of scientific results from a whole range of disciplines. Secondly, scientific progress has outstripped military affairs and is throwing out new possibilities for weapons development. Thirdly, before the Second World War it was, as a rule, the applied and technical sciences that influenced the development of weapons; but now basic research is coming to have a direct and immediate impact. Fourthly, all scientific research is relevant to defence: "now it is impossible to name with firm conviction any branch of natural science which would be neutral or unnecessary for the development of military affairs. Any branch of natural science either already takes part, or can potentially be used in military affairs." Fifthly, the creation, production, operation and control of modern military equipment is so complex that not only are scientists drawn in to work on military problems, but many officers have to become scientists in their own right.

Holloway suggested that the present nature of the interaction between the military and science derives from the competitive struggle with the West, the substantial military pressure to meet schedules and quality criteria, and the high priority and quality which the military demands for both material and personnel. With regard to attracting top people, he noted an interesting impediment which no doubt decreases the appeal of military science:

> The defence sector has first priority in the allocation of materials or parts which are in short supply. Engineering technical personnel in the defence sector are better paid than those in civilian industry, and, by and large, the workers also receive higher wages than in civilian production. It does not follow, however, that the quality of personnel is in fact higher, for many scientists and engineers, in particular those who seek recognition through publication of their work, find the secrecy stultifying and are thus not attracted by the higher pay.

Holloway mentioned another element in the military's connexion with science and with the economy, i.e., the fact that 42 per cent of the military production is directed to the civilian economy, mostly the transportation industry. Bush reports that according to the latest "best

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Western estimate " the military sector now absorbs between 11 and 13 per cent of the Soviet GNP (or even perhaps 14–15 per cent). Holloway asserted that the military's share of production of consumer goods would rise from 18 per cent in 1975 to an expected 22 per cent in 1980.

Historically, many of the important and more sophisticated military projects have been initiated under the aegis of the Academy and later separated from the Academy.

Weaknesses in Soviet Science

Soviet science may be considered " weak " if judged by Western standards; but use of another country's reference is not appropriate as a means for understanding the adequacy of Soviet science within the Soviet system. One criterion that may be used for that purpose is the relative self-sufficiency of the USSR in meeting its desires. This may not be a reasonable criterion for a country without natural resources, without a cultural environment receptive to the pursuit and use of science, or without effective communication with the industrialized world. The USSR is clearly free of such limitations. Therefore, any major requirement for imports by the USSR is a sign that there is inadequate organization and utilization of the country's resources—material, intellectual, and labour—to meet national objectives.

The frenzied efforts of the USSR to import Western technology partly reflects " weaknesses " in terms of this criterion. However, the principal reason for the lack of sufficiency results from the Soviets allowing the West to set standards for achievement. The Soviets have permitted themselves to be slaves to goals set by the West and not by their own objectives. An inevitable pressure then develops to turn towards the West for imported technology. Undoubtedly, the Soviets expect that this is a temporary condition, and that their desires and capacities will soon converge. The authors in these volumes expressed doubt that there can be such a convergence, given the fundamental sluggishness of the Soviet system.

Both Western and Soviet critics identify two paradoxes concerning the effectiveness of Soviet science as:

—If Soviet science and technology is so good, why import from the West?

—If the Soviet government wants to improve vertical integration why not remove it from the stifling bureaucracy, rigid planning, and emphasis on quotas?

Labedz comments directly on the first item:

> There are indeed many ironies in the situation. The Soviet system itself is allegedly based on a scientific theory (" scientific socialism "). Moreover, the prestige of science in the country has always been high, and yet even after being officially declared " the force of

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> production" in the new Marxist framework, the Soviet Union is forced to implement this belatedly discovered "scientific-technological revolution" by imports of Western technology.

Parrott discussed the unsettling ideological implications raised by the importation of Western science:

> Today, as in the past, the Soviet Union's economic and technological performance in comparison with that of Western countries has profound implications for Soviet military and political influence abroad. It also has serious implications for the Soviet elite's professed belief in their own political system as the most modern and dynamic.

Labedz suggests that this repeated reliance on the West may create a continuing dependence—and consequent weakness—such that the USSR becomes dependent on periodic infusions of Western technology. Presumably, this dependence should not be followed to the extreme where we would grossly underestimate the underlying strengths in the Soviet system. Nevertheless, the reliance on Western science started with the Tsars and has continued since then despite the changes in government. Holloway quoted Sutton, who sees Soviet innovation as a paradox—an extraordinary lack of effective indigenous innovation in the civilian sector versus effective procedures in the military sector.

These general comments are intended to indicate that the weaknesses in Soviet science are related to a complex mixture of the Soviet structure, the historical Russian psyche, and the Russian cultural background. Twelve weaknesses can be identified in the system:

1. *Party interference* in the affairs of science is described by Graham and Katsenelinboigen. The point is epitomized by Graham:

> At the 24th Party Congress in 1971 the Party statutes were revised to give Party organizations in fundamental research institutions greater control over research administration. The effects of this change in the statutes were felt primarily in the Academy of Sciences.

And Katsenelinboigen asserts that the Party interferes directly with economics:

> The Party apparatus is another user of the economists' work. The Party apparatus, as is well known, fulfils a dual role in Soviet society. On the one hand, it formulates and implements ideological policies. On the other, it intrudes directly into the economic life of the country and participates actively in the process of shaping and fulfilling economic plans.

2. *Inflexible planning*, a reflection of central authority, discourages productivity. Reorganizations in the late sixties to stimulate production increased the authority of the central organizations. Zaleski notes: "There is some evidence that research institutes are currently subject to tighter controls by the agencies to which they are accountable."

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Holloway considered the military rigidity and its effects. He pointed out that:

> One military writer has commented that "the search for a more flexible organizational structure for research establishments is one of the ways of raising the effectiveness of scientific research in the interests of the country's defence."

Parrott uses the term "taut planning" when he talks about rigid methods for planning:

> Taut planning also makes the participants less willing to accept the economic risks of innovation. All this is a familiar syndrome, but its consequences for technological innovation are graver than for other types of activity.

3. *The stifling effects of Russian bureaucracy* have been identified frequently in this discussion. The Soviets widely recognize the pervasiveness of bureaucracy which seems to be rooted in a cultural propensity for avoiding risk and responsibility. The cumbersome bureaucracy substantially diminishes the vitality of the economy.

4. *The pre-emption of resources by the military* diminishes the efficiency of the civilian sector. The military seems to have first call on scientists, institutions, instruments and other resources.

5. *Dependence on the West* for scientific input is a self-perpetuating weakness which may worsen with time.

6. *Resistance to technological change* and specifically to innovation in the industrial sector is widespread. Potential changes threaten the fulfilment of production quotas. Katsenelinboigen notes:

> . . . the threat that this might curtail the authority of the Soviet management apparatus, the inability to implement new methods of planning, etc., has led many Soviet managers to oppose the introduction of new economic methods.

7. *Lack of technical management and infrastructure* restricts the flow of industrial products and processes. Labedz points out that:

> It is obvious that for new technology to function effectively it is not sufficient to copy the hardware; it is also necessary to create an organizational and managerial infrastructure, as well as the pattern of rationality which would permit it. This raises the perennial problems of ideology versus rationality and of *apparatchiki* versus technocrats in the absorption of—say—computer technology into the Soviet system.

8. *Political influence* on science inhibits scientific personnel as well as institutions. While Soviet science is widely thought to be excellent by Western peers, Joravsky implies that its representatives do not always keep their allegiance to it, by choice or by force. Adams addresses the pliable ambivalence of Soviet science:

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> . . . Nor should we be surprised to find many Soviet scientists who have risked political difficulties to defend genetics now signing petitions against Sakharov: scientists speaking on political matters threaten to undo the symbiotic relationship predicated on the separation of science and politics and invite the kind of political interference in science which led to the Lysenko problem in the first place.

9. The *inability successfully to integrate science* into production and marketing seems to be a recurring theme when discussing Soviet weaknesses, according to Hanson, Fusfeld, Amann, Parrott, and others. Parrott, in analyzing the problem, points to the lack of incentives to promote competition. He concludes that the problems reside more in the rigid structure than with personnel.

10. *Slow diffusion of information* impedes scientific achievements. Hanson blames the sluggishness on low credibility attached to Soviet information on the one hand and to a predisposition of Soviet scientists to claim Western advances as their own. Other reasons for slow diffusion include lack of photocopying machines, a scarcity of advertising literature, and ineffective technical societies.

11. *Difficulties in relating science to broader economic goals* is discussed by Zaleski and Labedz. The former comments that:

> One of the greatest difficulties in planning science in the USSR is to relate it to broader economic goals. The difficulties encountered in this area have been noted continuously. Recently, the Soviet government made a special effort to solve this problem by devoting—for the first time—a special chapter in the national plans to the planning of science and technology. The effort attempts to link R & D with production by prescribing in detail the transfer of new technology and research results to the production process. . . .

Zaleski discusses a number of efforts to reorganize the research and development structure to strengthen the effect of science on economic growth.

12. *Poorly defined and underutilized economic incentives* for innovation undermine the effectiveness of scientific activities. It seems that honorary titles and medals are not enough compensation for the average Soviet citizen to increase his productivity.

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Science and the Soviet System

Leopold Labedz

ALTHOUGH there are many excellent studies on various aspects of the development of Russian science and its relation to the Soviet system,[1] the question as a whole has never been systematically and comprehensively analysed. But a general awareness of the problems involved is growing in the West, as manifested for instance in books by American correspondents in Moscow such as *Russia* by Robert G. Kaiser and *The Russians* by Hedrick Smith. Both these volumes provide relevant illustrations of the effects of the Soviet system on the strengths and weaknesses of Soviet science and technology. In particular they bring out, in telling detail, the stultifying effect of the administrative control of science and of the obstacles created by the secrecy and nature of Soviet planning. Kaiser concludes that Soviet scientific achievements " represent exceptions to the norm . . . and not the natural outgrowth of a well-balanced programme of scientific research. . . . The Russians may worship science and enshrine technology, but for the moment they live with an economy which actually resists new technology instead of absorbing it."

There are indeed many ironies in the situation. The Soviet system itself is allegedly based on a scientific theory (" scientific socialism "). Moreover, the prestige of science in the country has always been high, and yet even after being officially declared " the force of production " in the new Marxist framework, the Soviet Union is forced to implement this belatedly discovered " scientific-technological revolution " by imports of Western technology.

What are the reasons for this paradox? In a short article one can only indicate some salient points about the background and prospects of Soviet science.

First, one must look at the historical aspect. As with other elements of the Soviet system, the scientific establishment which was inherited from Tsarist Russia, shows many characteristics of its origin. Some of the conditions under which it functions, such as creative freedom, have deteriorated; others, such as the massive promotion of science by the state, have been enhanced. Yet in general one notices not just a continuity in Russian scientific tradition, in spite of all the upheavals, but also the recurrence of a specific problem which it had already faced in the past; the country's recidivist tendency to fall behind in the technological race, despite repeated efforts to overcome its backward-

[1] For instance: David Joravsky, *Soviet Marxism and Natural Science, 1917–1932*, Columbia University Press, 1961; Alexander Korol, *Soviet Education for Science and Technology*, Wiley and Sons. 1957; L. Graham, " The Development of Science Policy in the Soviet Union," in T. D. Long and C. Wright, *Science Policies of Industrialized Nations*, New York, 1975.

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ness. In trying to attain its economic goals, the Soviet system has created some of its own counter-productive problems, but in a historical perspective Soviet science seems to fall into the overall framework of what Brutzkus called "the peculiarity of Russian economic development." Its general traits were noted by many observers, from Trotsky to Gerschenkron; whatever the differences in the interpretation of its causes, its two fundamental features, whether under Peter the Great or under Brezhnev today, have been state direction of the economy and the need to rely on imports of technology. It may well be that the two elements are historically interconnected. In trying to catch up with the more advanced countries, the overwhelming role of the state not only contributes to the promotion of the process but may in the long run affect the internal dynamics of development by relying exclusively on administrative and bureaucratic controls and thereby weakening incentives and initiatives for innovation. The clash between such controls and scientific initiatives, between central direction and individual entrepreneurship, creates conditions inimical to technological innovation and thus makes it once more necessary to borrow technology from outside. It is an important factor affecting science as well as the economy.

Soviet science policy has reflected from the beginning some ancient problems in this field.[2] When Peter the Great founded the St Petersburg Academy of Sciences in 1724, it was given the task not only of carrying out scientific research but also of helping the government to solve practical problems. Its statute made it mandatory for its members to work on projects given to them by various departments of the government. With time these obligations fell into disuse as the academicians tended to pursue knowledge for its own sake. But the First World War and the October revolution in particular reversed this trend. The Soviet government under Lenin put before the Academy the task of helping it to implement its economic planning in general and its industrial policy in particular.[3] However, the Academy has once again shown a predilection towards pure rather than applied science. Under Stalin, between 1930 and 1953, the Academy was repeatedly reorganized to achieve a "strengthening of the ties between science and production." After Stalin, it underwent some further reorganizations and its role was further enhanced. While the post-Stalin science policy removed some of the obstacles to the pursuit of learning in various disciplines, the dilemmas of pure science versus applied science, of centralization versus decentralization, of governmental

[2] Cf. E. Zaleski et al., *Science Policy in the USSR*, Paris, 1969; Linda Lubrano Greenberg, "Soviet Science Policy and the Scientific Establishment," *Survey*, Vol. 17, No. 81; Autumn 1971, pp. 51–63; also her *Soviet Sociology of Science*, Columbus, Ohio, 1976; R. R. Gill, "Decision Making in Soviet Science Policy," *Bulletin of the Atomic Scientists*, No. 4, 1968, pp. 15–19.

[3] Cf. Alexander Vucinich, *The Soviet Academy of Sciences*, Stanford, 1956; L. Graham, *The Soviet Academy of Sciences and the Communist Party, 1927–1932*, Princeton, 1967.

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pressure to subordinate science to the requirements of the economic Plans versus the needs of fundamental scientific research have been as vexing as ever; indeed, in some respects the dilemmas—because of the growth of the economy and the increased role of science—have increased, in spite of the relaxation of the ideological grip on the natural sciences after 1956 and again after the fall of Lysenko [4] in the wake of Khrushchev's removal in 1964. Under Brezhnev all these old dilemmas have reappeared even more acutely.

Just as Khrushchev's treatment of Stalin's legacy held some fundamental internal contradictions, so has Brezhnev's handling of his inheritance from Khrushchev. The concentration of power under Stalin was combined with a planning system based on a control of the allocation of resources which permitted the achievement of goals which had priority (at the expense of the rest of the economy). Political terror and ideological surrealism did not prevent the relative success in the high priority fields of science and technology such as nuclear weapons and rocketry. But the economic, as well the social, price of such achievements was high: a gap emerged between science and the economic system. Moreover, there was no " spin-off " between military and civilian technology; secrecy and ideological controls over science compounded the shortcomings of the economy, which were due to the draining off of material and personnel resources to the high priority military and heavy industry projects. The psychological effect of terror discouraged innovation. Khrushchev's " de-stalinization " after 1956 removed some of these obstacles. Growing attention was devoted to the problem of technological innovation, and science was elevated to the status of a " productive force " in the new Party Programme at the 22nd Party Congress, with the implication that it would play a more fundamental role as part of " the material basis " and not merely as an aspect of the " superstructure." While terror abated and the ideological straitjacket over science was significantly loosened, new organizational measures were taken to stimulate applied science and improve domestic technical innovation and the handling of foreign technical information. But although the nightmare of the " Russia First " period of Stalin's scientific policy ended, the new measures to improve the effectiveness of applied science in the Soviet economy met with only limited success. The coordination of research was not made easier by the proliferation of agencies handling it; indeed the dispersal of R & D institutions following the *Sovnarkhozy* reform made it more difficult. Besides, " de-stalinization " in science, as elsewhere, was anything but thorough or consistent: Lysenko and Lysenkoites were not yet removed from the Soviet scientific establishment, even though their power was greatly diminished. The hopes for miracles in agriculture and industry were still alive; based partly on Stalin's own

[4] Cf. Zhores Z. Medvedev, *The Rise and Fall of T. D. Lysenko*, Columbia University Press, 1969; David Joravsky, *The Lysenko Affair*, Harvard University Press, 1970.

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premises, the overall Khrushchevian perspective was still based on the idea that the Soviet economic system permits higher investment than the capitalist one and that this will ultimately lead to the winning of the economic race with the West, both in terms of production and labour productivity. The lessons of Western post-war technological evolution and of Western experience with R & D were not easily learned. Administrative decentralization was resisted because it affected the vested interests of many bureaucrats at the centre. Then too, the rehabilitation of cybernetics produced the dream of the cybernetic system of centralized control; yet it has not been accompanied by the computerization of the Soviet economy. On the contrary it became clear that the Soviet Union was falling behind in the technological race with the United States, and this became particularly obvious in the fields of automation, computer technology and miniaturization techniques.

Khrushchev's de- and re-centralization schemes were condemned by his successors, who preferred a more cautious approach and avoided antagonizing the *apparatchiki*. The reform of the planning system, with its obsolete structure of controls and incentives, has been vitiated by political and social vested interests. The perspective of radical economic reform was abandoned at the 24th Party Congress. Contradictory pulls and considerations continue to affect Soviet science policy. Thus the abandonment of Khrushchevian "de-stalinization" was accompanied by the final abandonment of Lysenkoism. Fundamental economic reform was abandoned at a time when the Soviet leaders had realized the importance of the new industrial revolution in the West and dubbed it "the scientific-technological revolution." [5]

Soviet theoreticians maintain that while in "the capitalist countries technical policy must break its way through countless obstacles . . . in the socialist countries (it) can be formulated more deeply and more fully on the basis of objective possibilities and laws emanating from the totality of developments in science and technology at the given historical stage." [6] But this does not change the fact that the main flow of technology continues to be from the West to the East, that the Soviet Union is seeking Western scientific and technological know-how even more eagerly than before, and that it exploits the *détente* policy with the aim of a massive transfer of technology to cover the gap between the American practical achievements in science and the Soviet theory of the "scientific-technological revolution." We have

[5] On Soviet attitudes towards the "scientific-technological revolution," cf. Robbin Laird, "Post-Industrial Society East and West," *Survey*, Vol. 21, No. 97, Autumn 1975, pp. 1–17; T. H. Rigby and R. F. Miller, *Political and Economic Aspects of the Scientific and Technological Revolution in the USSR*, Canberra, 1976; Julian Cooper, "The Scientific and Technical Revolution in Soviet Theory," 1975 Bellagio Conference on Technology and Communist Culture; D. M. Gvishiani et al., *Nauchno-Tekhnicheskaya Revolutsiya i Izmeneniye Struktury Nauchnykh Kadrov*, Moscow, 1973.

[6] A. A. Zvorykin, "Rol' nauki v sozdanii materialno-teknicheskoi bazy kommunizma," in V. G. Afanasyev et al., *Problemy nauchnogo Kommunizma*, Moscow, 1966, p. 178.

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thus reached a point where not only the cyclical necessity to import innovation from outside[7] is particularly pronounced, but also one in which Brezhnev (who at the 24th Congress of the CPSU in 1971 stressed that the implementation of the "scientific-technological revolution" is a *sine qua non* of the building of a communist society) implies that the capitalist class enemies would provide him with the indispensable tools to achieve his goals: socialist construction, military superiority, etc.

The question which arises is not whether the Soviet Union will be capable in the future of generating the scientific innovations necessary to stay in the qualitative technological race, but the more immediate one of whether it is capable of absorbing sophisticated Western technology in time to catch up with the West, assuming that in one way or another such technology will be forthcoming.

The answer to this question depends on many variables, which include scientific and political, economic and social factors.

According to specialists in various scientific disciplines, Soviet science is patchy—strong in some fields and well behind the West in others.[8] The general tendency has been to underestimate it before *Sputnik* and to overestimate it afterwards. But at present a more discerning attitude prevails: we no longer hear about "the death of science in Russia" (the title of a book by Professor Zirkle), nor do the Soviet space achievements loom so large after the 1975 joint project Apollo-Soyuz.

A more balanced and differentiated analysis of the prospects of Soviet science and its role in the Soviet economic development is possible, as well as a more judicious assessment of the reciprocal effects in its relation to the Soviet system and to its current evolution.

[7] Cf. Antony C. Sutton, *Western Technology and Soviet Development*, Vols. I—III, Stanford, 1973; R. W. Campbell, "Problems of Technical Progress in the USSR," in M. Bernstein and D. Fusfeld (eds.), *The Soviet Economy*, 4th Edition, 1974; R. W. Judy, "The Case of Computer Technology," ibid.; Joseph S. Berliner, *The Innovation Decision in Soviet Industry*, Cambridge, Mass. and London, 1976; Laurence H. Theriot, "U.S. Governmental and Industry Cooperation with the Soviet Union in the Fields of Science and Technology" in *Soviet Economy in a New Perspective*, *Joint Economic Committee*, U.S. 94th Congress, 2nd Session, Washington, 1976; Philip Hanson, "Technology Transfer from the West to the USSR," ibid.; Fred G. Bucy, Jr. (ed.), *An Analysis of Export Control of U.S. Technology*, Office of the Director of Defense Research and Engineering, Washington, 1976; Alexander Wolynski, "L'aide Economique de l'Occident a l'URSS," in *Le Monde Moderne*, No. 13, Paris, 1976, pp. 13–40; *Transfer of Technology to the Soviet Union and Eastern Europe*, Committee of Governmental Affairs, U.S. Senate, 95th Congress, 1st Session, Washington, 1977; Frederick J. Fleron, Jr. (ed.), *Technology and Communist Culture*, New York and London, 1977; Christopher Saunders (ed.), *East-West Cooperation in Business*, Springer Verlag, Vienna and New York, 1977; also his *Industrial Policies and Technology Transfers between East and West*, *idem*; Victor Basiuk, *Technology, World Politics & American Policy*, *New York*, 1977; R. Amann, J. M. Cooper, R. W. Davies (eds.), *The Technological Level of Soviet Industry*, New Haven and London, 1977; J. Moscicki and K. Poznanski, "Patenty i Licencje w kontaktach ekonomicznych Wschod-Zachod (Patents and Licences in East-West Economic Relations)," *Sprawy Miedzynarodowe*, Warsaw, No. 1, 1978.

[8] Cf. Leopold Labedz and Walter Laqueur, *The State of Soviet Science*, The MIT Press, 1965; Yakov M. Rabkin, "Naukovedenie," *Minerva*, Spring 1976, and "Measuring Science in the USSR: Uses and Expectations," *Survey*, Vol. 22, No. 99, Spring 1976.

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It is obvious that for new technology to function effectively it is not sufficient to copy the hardware; it is also necessary to create an organizational and managerial infrastructure, as well as the pattern of rationality which would permit it. This raises the perennial problem of ideology versus rationality and of *apparatchiki* versus technocrats in the absorption of—say—computer technology into the Soviet system. This problem is obviously not just technical or organizational, because change in the administrative structure of controls involves change in the relative power and status of different categories, as well as the question of its effect on the legitimacy of the existing system. It touches both vested interests and the ingrained habits of thought and behaviour of the ideologically and socially conservative pillars of the Brezhnev regime. In this respect the issues and clashes of interest are similar to those involved in the aborted economic reform in which—as Harry Rigby put it—" what was at stake was nothing less than the traditional leading role of the Party in Soviet society." [9] Many Western analysts have suggested that from the viewpoint of the Soviet rulers the problem is one of political cost for economic efficiency; market mechanisms or computer technology threatening political controls, priorities and ultimately the Party's legitimacy itself. If the new techniques are to be introduced, this must be done in a way which would avoid the negative effects on the Party's rule.

But it is unlikely that *apparatchiki* will be replaced in the near future by technocrats in the Soviet political structure because of the effect of necessities imposed by science and technology on the Soviet system. It is arguable, however, that technocratic and " rationalistic " attitudes may slowly penetrate the mentality of the *apparatchiki.* Whether and to what extent this may happen is a question on an altogether different time scale. The evolution may in any case be seen historically not so much as a case of suborning the politicians by scientists, but of continuing the process of the adaptation of science to the Soviet system and of the ongoing " domestication " of scientists and technologists by the Party authorities.[10]

The " undomesticated " scientists, the dissidents (the Sakharovs, Orlovs, Leviches) are, so to speak, outside the problem of the evolution of the system. They can only play a role in political decision making if the present system is replaced by another one. This is not to say that dissident attitudes do not fall on fertile ground in a scientific milieu; this can be inferred from a surprising degree of solidarity with the dissidents displayed by other scientists and from the professional discontent among them caused by the Party controls and by the bureaucratization of Soviet science.

[9] Op. cit., p. 18; cf. also by the same author, " Politics in the Mono-Organizational Society," in Andrew C. Janos (ed.), *Authoritarian Politics in Communist Europe*, University of California, Berkeley, 1976, pp. 31–80.

[10] Cf. Leopold Labedz, " Soviet Science," in B. Barber, *Sociology of Science*, Columbia University Press, 1962.

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Such control over science is likely to remain tighter in the social and humanistic sciences because they are closer to the sensitive area pertaining to the legitimacy of the Soviet system. From this point of view the social sciences are therefore more dangerous than the natural sciences. The history of Soviet sociology—and of its definition—is a telling example.[11] But natural science is infinitely more important to the Soviet rulers. It also gives a far greater margin both to them and to the scientists to modify science policy and to adjust to it, so that the confrontation between them does not reach the point of escalation. Unless other forces join the act, the question remains one of balance. In this balance, the Soviet scientific establishment will, when the chips are down, accommodate itself to the requirements of the system, rather than vice versa.

[11] Cf. Ilya Zemtsov, "IKSI: The Moscow Institute of Applied Social Research," Soviet Institution Series, Paper No. 6, The Hebrew University of Jerusalem; also Robert C. Toth, "Soviet Sociology Institute Purged for Non-Marxist Findings," *International Herald Tribune*, 13 Oct. 1976.

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Political Authorities and the Learned Estate*

David Joravsky

THE two questions most often asked about the relationship between the Soviet political authorities and the scholarly community are whether the learned estate is a reservoir of political dissidence or conformity, and whether "ideologues" are giving way to "technocrats" among the political authorities. Put this way the questions seem unanswerable. The learned estate does not express its political attitudes directly, and "ideologue" and "technocrat" are categories that obscure rather than illuminate the political authorities' shifting attitudes towards the learned estate. The questions should be reformulated: what have been the evolving patterns of interaction between the autonomous scholarly authority of the USSR's learned estate and the superior political authority of state and Party leaders?

Normal interaction—cooperation and routine conflict in areas of mutual interest—has been studied mostly with respect to organizational arrangements considered in isolation, not with respect to the actual work done by scientists, their achievements and failures, and the reactions of political authorities. Mathematics and chemistry might be suitable for a pioneering study of the latter sort, to test the consequences of such Soviet-style interaction. More on this later. Most of this paper analyzes what has been studied most thoroughly: abnormal interaction, the conflict that has attended political invasion of various disciplines. Such studies—of philosophy and the social sciences, and, among the natural sciences, of biology, physics, agronomy, and neurophysiology—present abundant evidence of evolving mentalities and types of behaviour on both the political and scholarly sides.

On the scholarly side of such conflicts I note a scale of types, rising from acceptance to defiance of political authority, and, correspondingly, from abandonment to defence of autonomous thought. At one extreme is the *learned opportunist.* He knows the requirements of his discipline, but shows no moral commitment to uphold them against political condemnation. Then there is the *pliable man of principle.* In times of conflict he tries to be true to his discipline, while placating political authority by verbal play, by avoiding sensitive topics, or by other more or less minor concessions. Further up the gradient towards wilful individualism is the *intransigent specialist.* Within his discipline he will concede nothing to political authority except silence, if that is the only way

* The following is a summary of a recent study on political-scientific relations in the Soviet Union.

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he can avoid saying things his discipline tells him are untrue. Greater resistance to political authority is shown by the *Varangian*, as an admiring Soviet journalist described the scientist who not only defends truth within his discipline but ranges without, defending autonomous thought against political authority in other fields.

To make the classification complete we must add two types who do not properly belong to the learned estate, but are brought into it by the intervention of political authority. At the lower end of the scale, showing even less individualism than the learned opportunist, is the *ignorant opportunist*. He defers as a matter of course, without understanding, to whatever authority is dominant, scientific or political. At the upper end of the scale, showing even greater individualism than the Varangian, is the *militant ignoramus*. When his pet beliefs are at issue, he defers to no authority outside his own mind, scientific or political. He *uses* any authority that may support his crankish ideas.

These categories blend imperceptibly into each other; many individual scientists are borderline or hybrid cases; some change in time, sometimes drastically. Nevertheless, it is possible within each discipline to estimate gross distributions with considerable assurance, and to draw two important generalizations for the learned estate as a whole:

(1) The overwhelming majority of scholars and scientists have been either pliable men of principle (in fields of intense political intervention) or intransigent specialists (in fields of mild political intervention). Even in fields where political authority has intensively promoted militant ignoramuses and ignorant opportunists (the social sciences, biology, philosophy), those types never achieved total domination. That is another way of saying that pliable men of principle and intransigent specialists have managed to keep alive autonomous scholarly standards, and are constantly ready to regain the field when political authority begins to withdraw.

(2) Varangians have so far been quite scarce, varying in number and in boldness with the changing political climate, and by field. They have come mostly from disciplines that have known war at their philosophical frontier, such as physics, rather than from disciplines that have been devastated within, such as biology and the social sciences.

In short, Soviet scientists and scholars have stubbornly defended the professional autonomy of their separate disciplines, but little more than that. Some have made debilitating compromises in that defence, and some have been bravely uncompromising, but extremely few have shown any readiness, even in times of liberalization, to become self-appointed prophets of truth rather than licenced advisers on special topics.

I would venture two speculative extrapolations from this pattern:

(1) If a radical political intelligentsia is being reborn in the post-Stalin era, the learned estate is contributing not its fully-fledged

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members (with notable exceptions) but its abortions, people whose resistance to political authority comes on too early and too strong to permit complete initiation into the learned estate. Wider observation would lead us to expect that pattern; in any country initiation into the learned estate is a form of socialization, involving acquiescence in the whole social system that contains the academic sub-system. If I may borrow American terms to describe the process, " tenure," the institutionalized guarantee of " academic freedom," is almost always given to people who have proved that they do not need its protection. Why Soviet political authorities have been so slow to recognize that truth, or in other words, why they have so persistently withheld " tenure " from a learned estate that has persistently proved its docility, is a major problem for students of the Soviet system.

(2) If the political authorities decide to resume the liberalizing policies of the first decade after Stalin, they will not be acceding to manifest pressure consciously generated by the learned estate. They will be pursuing their own reasons of state.

Nevertheless, latent pressures have been generated by interaction with the learned estate, shaping the reasons of state that the leaders have invoked as they have moved into conflict with scholars in most fields, and then into retreat in some fields. Outsiders usually explain those zigzags by invoking abstractions: ideology, totalitarianism, and the Russian tradition—in opposition to other abstractions: practicality, technological imperatives, and Western influences. But these tags are either misleading or question-begging, or both. A genuine explanation must be sought in the historical record, in the explanations and significant silences of the Soviet leaders and their bureaucratic agents as they have pursued their tortuous course in and out of various disciplines.

Certain themes, constantly recurring in shifting forms and varying emphases among the many different fields of higher learning, fall into large historical patterns when they are studied long enough:

(1) The revolutionary leaders' initial worry about the openly expressed political hostility of the learned estate turned into an enduring, hysterical anxiety, as open expression of any political disagreement—not to speak of hostility—was suppressed. The turning point was Stalin's revolution from above, when the " bourgeois intelligentsia " was forcibly converted into " our own Soviet intelligentsia." After the conversion, conflict between political and scholarly authority was more widespread and more intense than before, a frustrating paradox to which Soviet leaders and their apologists are so painfully sensitive that they cannot discuss it forthrightly. Outside observers are free to note that suspicion naturally festers about coerced oaths of unquestioning submission, especially when questioning is an essential task required of the learned estate, and most of all when that essential questioning deals with human institutions and values, as it does in the social sciences and the humanities.

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(2) Insistence on immediate service of the state's practical needs, with practicality determined by authoritarian political leaders, was another product of Stalin's revolution from above. It has precipitated many conflicts with learned specialists, who have autonomous criteria of practicality. In response to such conflicts political authorities have repeatedly promoted opportunists and ignoramuses who endorse the bosses' intuitive perception of practicality. When that perception changes, the favoured advisers are changed, sometimes for a new group of less obvious yes-men, sometimes for genuinely autonomous scholars or scientists. This has been a major cause of the notorious zigzags of party policy in such disciplines as biology, economics and history. In a few cases the political authorities went all the way, to the complete destruction of scholarly communities, before starting back towards normality. In industrial psychology (*psikhotekhnika*), social psychology, and sociology for example, the Stalinist extreme of arrogant faith in the bosses' intuitive criteria of practicality brought about the abolition of the scholarly disciplines, and retreat from that self-defeating extreme has brought grudging restoration of the disciplines.

(3) The regime's legitimacy rests, in part, on the leaders' claim that their decisions are guided by science, Marxism-Leninism. This claim requires, or has long seemed to them to require, demonstrations that it fits coherently into all branches of scientific knowledge, including political science. In fact, modern scholarly knowledge is badly fragmented, and the leaders' thought patterns have little relationship with any fragment, not even with Marx's version of social science and its living continuation. Hence the persistent revulsion against modernism, the tendency towards archaism or even towards anti-intellectual primitivism, within the bureaucracy that has the job of demonstrating the coherent fit of all knowledge with the Marxist-Leninist science that justifies the leader's decisions.

Outside observers can readily see an inverse correlation in all three historical patterns. Expansion of scholarly autonomy is implicitly linked with restriction of political authority, and vice versa. ("Implicitly" must be stressed, for this topic has not been openly discussed since the twenties). It is therefore tempting to classify Soviet political authorities on a scale running from one extreme to the other in the correlation of political and scholarly authority, as I did for Soviet scientists and scholars. ("Technocrat" and "ideologue" are a crude and misleading version of such a scale: crude in the either-or use of only two types, misleading in defining the types by reference to the problem of technology and ideology rather than to the problem of scholarly and political authority.)

Unfortunately, one cannot study the minds of individual Soviet politicians as one can those of scientists, for the political process is so organized as to suppress most evidence of individuality. Debate is

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mostly in private; unanimity is stressed in every policy shift; winners outdo the chameleon in inconsistency, and losers depart silently or, worse yet, with the winners telling us what vicious consistency caused their fall. Thus the collective mind is put on view. So it is possible, by studying changing policies and their justifications, to discern the changing collective mentalities of the political hierarchy.

For example, the third theme listed above (philosophical or intellectual concern) has been declining in force as Soviet leaders have been drifting towards the characteristic intellectual indifference of contemporary rulers. Everywhere modern knowledge is incompatible with the old faiths invoked to sanctify the state, but rulers have ceased to care. The reconciliation of knowledge and faith is left to ghettoized theologians or philosophers, whose efforts are largely ignored by the rest of the learned estate, not to speak of the political authorities. A Soviet analogue of this worldwide process has been under way, with a tardiness and a pain that are due in large part to the insistence that the sanctifying faith is scientific knowledge itself.

The first and second themes (hysterical fear of disloyalty, confusion between political and scientific criteria of practicality) have been receding much more slowly and unevenly. The retreat is only beginning in the social sciences, but it is far advanced in the natural sciences, where scandalous conflict between scientific and political authority has virtually ceased. On crucial issues pitting scientific against political criteria of practicality, there seem to be private debates, paralleling the controversies we are familiar with in such matters as resource conservation, medical research, or space programmes. My point here is that these debates have become normal; they do not precipitate political invasion of scientific disciplines.

MANY people think that the present condition is quite stable, that the leaders feel no great or growing pressures for important change. It is true that articulated demands for significant reform are rare and repressed. But latent pressures are probably working against the immobility of official policy:

(1) In philosophy, the social sciences, and the humanities, political and scholarly authority are still entangled and constantly threatening disruption. Some autonomous scholarly authority is essential to the political authorities, if only to meet their need for usable economic plans or credible history textbooks. But autonomous scholarship is bound to produce ideas that differ from some of the leaders' views, thereby provoking either conflict or further political withdrawal from the disciplines at issue. The choice is not easy. A reduction of scholarly autonomy threatens the essential services provided by economists or historians; an increase threatens the "leading role" of "the Party" (i.e. of political authorities) in economic planning and the inculcation of civic values.

(2) The Soviet record of creativity and of achievement is generally

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unsatisfactory in the natural as well as the social sciences, whether measured by international reputation, or by self-appraisal (compulsive boasting is evidence of an inferiority complex), or by technological progress. Soviet leaders are aware of the problem and are concerned to correct it.

The disappointing results cannot be ascribed solely or even mostly to the conflict between the political authorities and the learned estate. Achievement has been disappointing in fields such as chemistry, where conflict has been negligible, and in the medical sciences, where it has been slight, and in biology, where it has been terminated for more than a decade. (Physics is a peculiar case. Soviet physicists did the work that earned their six Nobel prizes in the period from the thirties to the early fifties, while conflict raged at the philosophical level of the discipline. Since the mid-fifties their conditions of work have been as normal as those of chemistry or the medical sciences, and as unproductive of the breakthroughs that earn Nobel prizes). On the other hand, Soviet mathematics enjoys a reputation for an exceptionally high level of achievement maintained over a long period of time.

A careful, comparative study of Soviet chemistry and mathematics would show, I think, that their levels of achievement have in fact been significantly different, and that the explanation lies in the contrast between the complex social organization of chemical research and the individualistic simplicity of mathematical research. In any country, it has been argued, the increasingly complex social organization of modern research tends to hobble creativity. The Soviet version of such organization, and the general ethos of Soviet society, with its exceptional stress on centralization and authoritarianism, seem to be exceptionally effective in hobbling creativity and in encouraging slack and conformist spirits. The syndrome has been repeatedly deplored by Soviet leaders, including Stalin himself. They lament the weakness of *samodeyatel'nost'* (spontaneity in the sense of self-activation, initiative), but they condemn *stikhiinost'* (spontaneity in the sense of elemental action, threatening disorder), and they continue to regard unlimited *vlast'* (power, political authority) as the chief means of limiting disorder, while encouraging self-activating improvement in society. It is possible to hope that interaction with the learned estate has been moving Soviet political authorities away from those sterile contradictions, towards the dialectical concept of creative disorder.

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Planning and Soviet Science*

Aron Katsenelinboigen

AS a discipline, Soviet economics can be viewed in two ways. First, it can be considered a part of the Marxist ideological conception and at the same time as an instrument for economic development. In this context, the role of economic science in Soviet society is seemingly greater than it is in the West. This is due to the fact that economics is given decisive weight in Marxist ideology. Thus, *Das Kapital* is the most fundamental work in the Marxist library. Secondly, the introduction of a planning system in the USSR as a definitive mode of operations required a more developed economic science. Then, too, the necessity of substituting centralized decision-making for many automatically acting market mechanisms required an elaborate conception of management structure.

Such a dual role of economics in Soviet society defines both the multi-layered structure of the institutions which develop economic science, and the multiple relationships between the economists and those who make use of their work. The latter appear to be found both among the managers of the economy and in the Party apparatus.

Management personnel is interested mainly in the results of the economists' work from the standpoint of possibly improving methods of planning and management. Of course, if the improvements proposed by economists conflict with the interests of managers, then these improvements will not be implemented in any case. A proposal introducing optimal planning methods can serve as an example: the threat that this might curtail the authority of the Soviet management apparatus, the inability to implement new methods of planning, etc., has led many Soviet managers to oppose the introduction of new economic methods.

The Party apparatus is another user of the economists' work. As is well known, the Party apparatus fulfils a dual role in Soviet society. On the one hand, it formulates and implements ideological policies. On the other hand, it intrudes directly into the economic life of the country and participates actively in the process of shaping and fulfilling economic plans. This dual role of the Party apparatus is the basis for the complex relationships it has with both economists and managerial personnel.

* This article was originally translated from Russian by Valerie Legan, a graduate student in the Department of Slavic Languages at the University of Pennsylvania. It is an extension of my article "Conflicting Trends in Soviet Economics in the Post-Stalinist Era," *The Russian Review* Vol 35, No. 4, 1976, pp. 373–99. A more detailed presentation of the issues dealt with in this article is given in *Limited Diversity: The Renaissance of Economics, Soviet Style*, a volume being prepared for publication by the author.

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One can note in particular, that the dual role of the Party apparatus has a negative influence on the activities of scientific research institutions. This is apparent, for example, from the fact that the Party apparatus has, in the past, diverted staff members of these institutes from their programme work. The Party apparatus uses these researchers to conduct ideological work which the apparatus considers of primary importance. This could include lecturing on economic topics in support of the most important aspects of Communist ideology. Further, the Party apparatus uses researchers in order to justify many activities of different branches of the economy.

The fact that the economic institutes are located in large cities ensures that the staff is subjected to exploitation by at least three levels of hierarchy—the Central Committee, the Urban Committees and the Regional Committees.

For example, when I worked at the Institute of Economics of the Academy of Science of the USSR in Moscow, I was often diverted from my regular programme work to complete assignments not only for for Central Committee (e.g. preparing material for the regular plenary sessions, answering letters of Soviet citizens addressed to the Central Committee concerning proposals for improving the performance of the Soviet economy), but also for the Regional Party Committee, which consisted of checking the activities of factories located in the region. Leading scientists participated and it was customary for the director of the institute, or his deputy, depending on the importance of the assignment, to choose staff economists also to participate. By fawning on the Party apparatus in this way, the director or his deputies would demonstrate how seriously they took the Party assignments. Depending on the complexity of the task, participants might spend several months exclusively on such political work at the expense of their regular work, doing so because the political assignment was usually considered incomparably more important than any other.

If the economists had taken their political assignments seriously, they would have had no time for their own professional work. Fortunately, it was known that the Party gave them simply in order formally to discharge its own responsibilities towards fulfilling its current plan of work.

After quickly comprehending the intent of these assignments, I personally spent only one or two days on them rather than the several weeks which might otherwise have been required. Sometimes I even contrived to receive " thanks " for doing a good job from the leaders of the institute. I believe that my experience is not unique. In spite of the shrewdness shown by scientists in carrying out the Party assignments only perfunctorily, they spend considerable time on these tasks, especially on giving lectures. Moreover, the political tasks degrade the professional pride of the scientists because they are inspired to carry out these assignments only in a slipshod fashion.

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ESTABLISHING communication between production workers and scientists is extremely difficult in all countries. The number of scientists in all countries is very small. Moreover, there is incompatibility between the executives and the scientists because of differences in their functions. Executives are responsible primarily for current problems. Therefore, they are interested in proposals for solving problems which take into account the constraints imposed by the current operating system. By contrast, scientists are primarily occupied with eliminating these constraints. But time is needed for this; as a result, the scientists are orientated towards the future, often on a long-term basis.

The less well-educated the political leaders are, the tenser the relationships between the scientists and the executives. The analogy of a chain can characterize the relationship between the two groups. Thus, if scientists work in highly abstract areas of science (which is to promise a profound understanding of the mechanism for a perfectly operating system) and if the socio-economic education of the country's leaders is low, then the length of the comprehension chain between the scientists and the leaders will be the longest. This means that more intermediary links are needed to translate the ideas of the scientists into language comprehensible to that type of leadership. In Stalin's USSR this chain was relatively short because scientists were not permitted to develop new ideas. Moreover, there were gaps in this chain because the leaders, being primarily professional revolutionaries, were by definition incapable of absorbing new scientific ideas.

After Stalin's death, the situation changed somewhat. Theoretical economists were permitted to study more basic questions, but only within very strict limits, e.g. a discussion of the possible introduction of large-scale private ownership was prohibited. In addition, the composition of the staff serving the Soviet leaders had changed. They were now primarily engineers.[1]

As these changes occurred, the chain between scientists and practitioners became longer. At the same time, the leaders became more receptive to new proposals. Naturally, this receptivity could be exploited if the issues were presented to the leaders in a comprehensible form. But numerous links are needed to accomplish this.[2] Although there

[1] This even concerned *Gosplan* in the USSR where leading personnel among professional economists were replaced by engineers. The question of the final character of this change requires further study.

[2] In the late sixties, a representative of the scholarly community tried to explain to a leader of *Gosplan* the idea of optimal planning and the possibility of a simultaneous formation of the plan and prices. Despite the fact that this representative was a "semi-scholar," he was not able to explain these ideas to the *Gosplan* leader. The latter informed his interlocutor that had he not formerly known him as one with common sense, he would have considered him just as insane as the scholars who elaborated the theory of optimal planning. It is possible to understand the reaction of the *Gosplan* leader. As a man with common sense, he knew that he was responsible for compiling plans in physical terms. The formation of prices based on *past* expenditures is done by a special organization—the State Committee for Prices. Therefore, how can prices be supplied together with the plan under these circumstances?

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are still gaps in the communications chain, new intermediary links between Soviet leaders and scientists have nevertheless been forged.

The use of consultants by the Central Committee in the late fifties can be considered one of the most important connecting links.[3] The advantage of using consultants was essentially based on the idea that they are not tied down to operational work. Hence consultants are supposed to prepare proposals for the solution of specific problems. To carry out such work, scientists from research institutions were invited as consultants. Though they have varying capabilities and qualifications, there is evidence that highly competent consultants are present in several sections of the Central Committee. To assess their role and the performance of other planning specialists, one has to examine several aspects of the relationship between Soviet economists and those who use their work.

ECONOMIC science in the USSR is developed in three types of institutes: institutes of higher education (VUZy) and the research institutes of the Academy of Sciences and of the ministries.

Work on economics in VUZy is directed primarily towards the strengthening of ideology. This situation is the result of the nature and role of higher education in the Soviet Union. Since Party and government leaders are extremely concerned about their political base, they try above all to prevent any political activity by the student body.

Therefore, the political leaders first of all require the professional staff of VUZy to direct their efforts to the strengthening of ideology. Under such conditions, scholars prefer to work not at the VUZy, but at research institutes where the political problems are relatively less pressing.[4] Despite this preference, scholars find it necessary to compromise and work part-time at the VUZy in order to broaden their knowledge and to supplement their incomes. Further, Soviet leaders

[3] As far as I know, the first consultant position was granted in the Department for Relations with the Socialist Countries of the Party Central Committee when it was headed by Y. Andropov. F. Burlatsky was the first chairman of the consulting group of this section. G. Arbatov then took his place. Both Burlatsky and Arbatov belong to the part of the new generation with more open minds on many complicated problems and some interest in scholarly research.

[4] The conservatism which is prevalent in Soviet VUZy is not absolute. There are occasional oases. Several of the advocates of the economic reform of 1965, e.g. E. Liberman and A. Birman, were professors at VUZy. In the late 1950s a group of professors of the Moscow Institute of the National Economy, including M. Breev, S. Field, I. Popov, and B. Smekhov, played a major creative role in forming a new direction for Soviet economics—a mathematical modelling. In the early sixties a new discipline was organized at the economics faculty of Moscow University. This discipline—economic cybernetics—was successfully organized owing to the fact that (1) a progressive leader such as I. Petrovsky had been head of the University for a fairly long time, and (2) a progressive economist such as V. Nemchinov aspired to organize the economics education in a new way. As a result, two different programmes for the preparation of students exist in the same faculty. One programme takes into account current achievements of economics under the aegis of economic cybernetics, while the other ignores these achievements. But the mere fact of the "existence" of these two programmes stimulates the work of the traditional professors of the department. Among these professors are also supporters of new directions in economics.

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understand the need for teaching students new methods of planning and management in order to improve the economic mechanism. The VUZy provide the forum for this teaching.

Conversely, the state also tries to use teachers of economics at the VUZy to do scientific research, so that support of ideology is not their only task. This aim is enhanced by the fact that a significant number of VUZy economists offer courses of an applied character. In connection with the research objective, so-called "accounting laboratories" (*khozraschetnye laboratorii*), which are not financed by the state, have been created in many economics departments of VUZy. Their personnel work under contracts with enterprises. It seems to me that the research conducted in these laboratories is not effective because the professional competence of the staff is low.

Academic institutes of economics are faced with a dilemma. On the one hand, as offshoots of the ideological sections of the Central Committee apparatus, they are required to deal with the ideological consolidation of Soviet power. On the other hand, both the Central Committee apparatus and the top economic management responsible for overseeing the economy want to obtain recommendations from economics institutes for improving the direction of the USSR economy.

To this it is necessary to add that in the very apparatus of the Central Committee there are groups which are at war with each other. They have diverging opinions on how the mechanism of management should be perfected.[5]

For a closer look, it is interesting to examine the role of two leading economics institutes: the Institute of Economics and the Central Economic-Mathematical Institute (TsEMI). Both institutes play a significant role in Soviet society. As ideological centres, both exert direct influence on practical decisions of the central bodies of the Party.[6] I would like to touch briefly upon the relationship between the Party and the economic apparatus management as it concerns these two leading academic institutes.

The Institute of Economics has for many years dealt primarily with ideology. However, in the mid-sixties, members of the Institute took an active part in formulating proposals for economic reform with the support of some leaders in the Party's Central Committee. It would not be an exaggeration to say that this Institute was the chief headquarters for the advocates of reform. For although many theoretical principles employed as the basis of reform corresponded to traditional Marxist precepts, the proposed reform on the whole required *decentralization*

[5] Indirect proof of this instance is, for example, the fact that for many years the chair positions in planning and financing were not filled. These positions are directly linked to the formulation of economic policies and the make-up of the governing departments of the economic management apparatus.

[6] I somehow managed to propose the following criterion for measuring the social significance of an institute: the number of letters which a given institute receives from the insane.

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and a possible *diminution* of the Party's role in the national economy. Consequently, many members of the Institute, even those supporting some reform, were opposed to new directions in economics, designed to promote mathematical economics. In the early seventies, when reform attempts were all but abandoned, the Institute of Economics was subjected to sharp criticism in a resolution of the Central Committee. The Institute was re-orientated towards studying ideology in the context of traditional Marxist ideas.

The Central Economic-Mathematical Institute, created in 1963, studies primarily optimal planning. The concept of optimal planning is based on new theoretical ideas which clearly require re-examination of many obsolete Marxist concepts. While preserving centralized management of the economy, optimal planning is linked primarily to *deconcentrating information*. The Institute is and has been subjected to criticism by *Gosplan* for its anti-Marxist views and similar sins. This criticism is supported by leading members of the Central Committee apparatus. At the same time, however, the Institute is supported by some Party organs and other leaders in the apparatus, especially in recent years.

Conflict between the TsEMI and *Gosplan* was precipitated by the fact that *Gosplan* opposes new methods of planning (which can be expected of any organization striving to preserve its status).[7]

[7] In this connection, it is interesting to mention the contacts which have been observed between two warring organizations such as *Gosplan* and TsEMI of the Academy of Sciences.

In the early sixties a series of resolutions from the Soviet government greatly promoted the development of the methods of optimal planning. According to one of these resolutions, *Gosplan* created a special department for the application of mathematical methods and computers in the management of the Soviet economy. V. Pugachev, who formerly served in TsEMI, worked as the deputy of this department in 1964. Until this time, Pugachev had several general ideas for organizing the economy on the basis of optimal planning and wanted to carry them out. He was successful in obtaining *Gosplan's* agreement to develop elaborations of branch optimal plans. To accomplish this he also obtained a decision to create the necessary groups in the branch research institutes.

However, due to the opposition to new ideas and to " impulsive intuition " exhibited by the apparatus of *Gosplan*, Pugachev left *Gosplan* and returned to TsEMI. He continued as the head of a laboratory and of the department which worked on problems of establishing a hierarchical system of optimal planning.

V. Kosov, who worked at TsEMI, succeeded Pugachev at *Gosplan*. The department which applied mathematical methods and computers to the management of the economy, was not productive because of opposition in other departments of *Gosplan*, and opposition due to professional inadequacies of many specialists working at *Gosplan*.

In the late sixties the death of the chief of this department, J. Oblomsky, gave the leadership of *Gosplan* the opportunity to terminate this department. However, *Gosplan* still found it necessary to preserve the appearance of supporting new methods of planning. Such was the spirit of the times. A sub-department in the *Gosplan* department on long-range planning, which was to prepare summaries, was established, with responsibility for the same functions as the disbanded department, viz. the application of mathematical methods and computers to the management of the economy. V. Kosov was appointed deputy chief of this long-range planning department of *Gosplan*. He was accountable for the work of the new sub-department.

Kosov is known as a specialist in the field of input/output tables. For a long time he was not favourably inclined towards the idea of optimal planning, primarily because he was unfamiliar with this approach. But Kosov and Pugachev are also known for their pragmatic views and are considered by some to be unscrupulous in pursuing their

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Some leaders of the Party apparatus support TsEMI, in spite of a degree of ideological inconvenience caused by the Institute.[8] They view the work of the Institute as a promising means for raising the effectiveness of the economy within a centralized system while still preserving the powerful influence of the Party.

I do not know which leaders in the Central Committee support both the Institute of Economics and TsEMI. While one can safely assume that such support does not overlap across the board, one can expect that some leaders support both institutes.

In any case, the relationship of the Party apparatus toward TsEMI shows that some leaders of the Central Committee are extremely sympathetic towards the preservation of a centralized economic system, even if it is necessary somewhat to modernize and de-ideologize the Soviet system. What motivates the Party leaders who react against the TsEMI directly is difficult to say. They may be very conservative people who want to maintain the status quo. Or they may be those like the supporters of the 1965 economic reform.

Many researchers in economics are occupied with applied economics both at the national level and at the level of individual branches and regions. These economists work either in specialized economic research institutes, or in economic sections of technological institutes and construction bureaux. All of these institutes and bureaux belong to appropriate governmental departments and ministries.[9] Of course, it is necessary for all economists who work in these institutes to adhere to the ideological mandates of the Party. However, this requirement is relatively weak. It is important to note that economists who are

careers. I think that their inclination towards using methods of optimal planning was motivated by the possibility of receiving greater personal benefit, and it may have been further strengthened by the support of optimal planning, as I already mentioned, by several extremely conservative members of the Politburo.

The evidence for the close collaboration between Kosov and Pugachev is primarily their joint article, "The Multi-Stage System of Optimizing Calculations of Long-Range Economic Plans," published in the journal *Planned Economy* (No. 10, 1974).

Further, V. Kosov and F. Kotov published in *Planned Economy* (No. 4, 1976) a review of *The System of Optimal Planning of the Economy*, written by two TsEMI collaborators, V. Danilov-Danilyan and M. Zavelsky. This book, as well as other similar work published by TsEMI researchers, was subjected to severe criticism in this review. Only Pugachev's work was excepted because the reviewers considered that it is "utilized in *Gosplan* for calculating the long-range plan."

[8] In the early seventies, M. Solomentsev, a candidate member of the Politburo, visited TsEMI. This was an unusual visit, since as a rule leaders of the institute usually go to the Central Committee and not vice versa. In speaking with leaders of the institute, Solomentsev discussed specifically the possibility that the institute could construct a five-year plan for the development of the national economy parallel to the plan prepared by *Gosplan*. While there may have been many reasons why Solomentsev needed a parallel plan, one thing is clear: it is doubtful that Solomentsev was favourably disposed toward *Gosplan*.

[9] Sometimes these institutes are called laboratories. This oversimplifies the bureaucratic procedure involved in the formation of these research institutes. To clarify any misconception it should be noted that directors of laboratories have fewer rights than those of institutes. But the establishment of a laboratory presumes its eventual transformation into an institute with independent rights.

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occupied in these research institutes are viewed by ministry officials first of all as an extension of the ministry's apparatus. This means that the personnel of these research institutions are quite often utilized to perform the functions of the ministry staff.

Special groups are created in many branch research institutes; these include economists and mathematicians who develop new methods of planning and more precise methods of optimal planning. Relations between these scholars and ministry staff are quite tense. There are numerous reasons for the reciprocal dissatisfaction. For example, the practitioners criticize the scholars for not considering an array of important constraints in their models of optimal planning. They also claim that the proposed models are too simple because they do not reflect the stochastics of the economics process. These criticisms are quite reasonable, but one must note that methods currently used also suffer from many of the same inadequacies. More than that, the diffusion of planning has additional importance to the practitioners because it allows them to solve some problems connected with consolidating their power.

Of course, the relationship between ministry personnel and directors of enterprises depends on the size of the plan assigned to an enterprise. Then, too, the choice of sites for building new factories, as specified in the plan, determines to a large extent the relations between ministry personnel and the Party apparatus, especially members of the local Party organizations. In any case, since it is not acceptable to reject new methods of planning, the more discriminating ministry leaders try to use new methods of planning, with the accompanying mathematics and computers, to substantiate decisions they have already made.[10]

NEXT, I want to make several general observations on the introduction of new ideas in branch institutes groups which deal with optimal planning. To effect a substantial change in a production technology, i.e. in the process of producing machines, it is necessary to stop current production in operating plants in order to replace outdated with new equipment. Only comparatively minor technological changes can be made in the production process without halting production. But a stoppage of current production can have substantial negative consequences. In view of this, the introduction of major new technological processes, which would interfere substantially with existing production, is achieved in many cases alongside on-going production. Only after the new technology is installed and working in the new enterprises are the old production lines shut down.

[10] Thus, for example, specialists in optimal planning were drafted to substantiate the necessity of building a factory for the production of cars such as the famous "Zhiguli" (Fiat). Since the decision was predetermined, specialists merely had to "substantiate" the rationality of the decision. Still, this decision was not easy. For example, there was a dilemma over whether to build one large factory in one place or to build several small factories in several towns, where labour, energy and housing funds were available.

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There is an analogous situation in the management of the Soviet economy which also has its own technology. For example, one can view the methods of optimal planning as a substantially new technological process of management. To introduce optimal planning, it is impossible to stop the current operations of *Gosplan* because this would paralyze management of the planned Soviet system.

In spite of this difficulty, it is possible to introduce optimal planning into *Gosplan* even as it carries on its work. In practice this means that for use of *Gosplan* and ministries, parallel organizations can be formed (at lower levels, if necessary) to develop optimal plans. In essence, the groups involved in optimal planning in branch research institutes could be viewed as sources of support to ministries. Similarly, the Main Computer Centre of *Gosplan* can be regarded as the embryo of such a support organization at *Gosplan.* The Central Economic-Mathematical Institute can be viewed as the organization for developing new technology.

Naturally, it is extremely difficult to coordinate the activities of all the groups noted and the organizations they support. In many respects they function independently. Moreover, they function in a strongly competitive setting, as already pointed out above. But, in spite of all these difficulties, the idea of establishing a parallel system of planning is gradually forcing its way into reality. It seems to me that this dynamic process can be regulated after establishing a special institution for coordinating the activities of all personnel involved in creating a new system of planning.

FINALLY, I should comment on the personal motives of management and Party leaders which define their relations with the scientific-economic community. An autocratic system engenders some pointed questions concerning the legal guarantees [11] for management staff and the safeguarding of its status regardless of its position at a given time.[12] The type of reward depends on the nature of products put out by the staff. If the staff produces "market commodities" it will want these rewards in the form of higher monetary income in exchange for the value that the members add individually. It seems, however, that the leaders

[11] Since the salaries of the USSR's leaders are quite low, it is difficult for them to accumulate money which can give them independence. Extra income consists rather of income in kind and perquisites (summer homes, cars, etc.). The latter remain the property of the state, however. One can assume that the higher the position a person occupies in the hierarchy, the greater role these material payments play in his income. When a person loses his position, he loses these material benefits. (When he retires he loses only part of the benefits.) One of the reasons for the mass corruption found in the leadership seems to be linked precisely with their desire to use their position to amass goods in case they lose their positions in the future. One can assume that the higher the position occupied in the hierarchy, the greater the role of bribes to supplement income.

[12] An interesting analysis of the tendency towards making Soviet society more elitist is given by A. Yanov in his work *The Domestic Roots of Soviet Foreign Policy*, Institute of International Studies, University of California, Berkeley, 1976.

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do not want to (or cannot) give the producers of these goods any significant guaranteed incomes at levels proportional to any profits which may result from their performance. If the staff produces goods then the staff will want rewards above all in the form of special privileges. One such privilege in the USSR is the receipt of scholarly titles and degrees. These titles and degrees ensure the corresponding privileges which are usually connected with specific jobs, but sometimes these privileges can be independent of a given job.

The possession of academic titles is the greatest privilege since it guarantees the bearer a sum of money irrespective of whether or not he is working. This sum is quite significant: an Academician receives 6,000 rubles per annum and a Corresponding Member of the Academy of Sciences receives 3,000 rubles per annum.

The possession of doctoral and *kandidat* degrees is also extremely rewarding. Degrees ensure the bearers of receiving appropriate positions in research institutions and also of giving them direct monetary increments. The scholarly degrees also make it easier for the bearer to receive the rank of associate or full professor in VUZy, with corresponding increases in salary.

Based on the above situation, both Party and management leaders have a definite interest in receiving scholarly degrees and titles. But they are unwilling (or unable) to spend time on taking exams and writing dissertations necessary to receive higher degrees. They look for any means to avoid taking the examinations, such as using subordinates to write dissertations.[13] All of this inevitably leads to close, informal contacts among Party and management leaders, and staffs of VUZy and research institutes in which the defence of dissertations takes place.[14]

The existence of many institutes studying ideology has the potential for giving rise to diverse opinions. During Stalin's time this diversity was suppressed sharply by an officially expressed unified point of view which was solidified by issuing the so-called "stable textbooks." A stable textbook was the only textbook in a given discipline. The stable

[13] Sometimes matters reach a ludicrous stage when these people do not have time to defend their dissertations. One incident making the rounds in Moscow relates to how Mitrofanov had his dissertation defended. (He was one of the secretaries of the Leningrad Province Communist Party.) He submitted his dissertation for the degree of doctor of economic sciences to the Moscow Engineering-Economics Institute. However, he did not show up for the defence of his dissertation; instead, he was representd by his assistant. The chairman of the scholarly council announced the candidate's absence to those who assembled and explained that at that given moment the candidate was occupied with executing an important state assignment. The dissertation was defended by the assistant and Mitrofanov received the degree.

[14] It can be assumed that the circumstances noted above exert a major influence on the struggle between Party organs at various hierarchical levels for the right to influence the activities of scientific institutes and the direction of their scientific work. For example, the Moscow City Committee of the Party tried to dispute the right of the Party's Central Committee to influence scientific institutes situated in Moscow. But judging by the fact that the organizer of this struggle, Yagodkin, the Secretary of the Party's Moscow City Committee, was not re-elected to the membership of the Central Committee at the last (25th) Congress, the Central Committee scored a victory in this struggle.

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textbook on political economy was produced personally by the " greatest Soviet economist "—Stalin.

In the post-Stalin era the situation has changed, as I have already said, and VUZy and research institutes have been able to publish their own textbooks. Several textbooks on political economy are now available. The differences between these textbooks are not that great, but the very fact that diversity exists is important.

Moreover, in the textbook written by the Department of Political Economy of Moscow University, an important chapter is dedicated to economic effectiveness of investment. In this chapter, the importance of introducing an " investment recoupment period " was noted. (Such a period is based on a conception of the rate of interest.) It should be noted that for a long time in the USSR this indicator was considered to be a bourgeois concept.

I would like to note that even such limited diversity does not gain unanimous approval. Among several members of the Party apparatus, there is a view point that it is necessary to liquidate this diversity and return to stable textbooks. (On this, see S. Trapeznikov's " Development of Economics in Accordance with the Needs of Contemporary Problems," *Voprosy Ekonomiki*, No. 3, 1974.)

It is difficult to say at this time what the future of economics in the USSR will be. Will it succeed in maintaining diversity or will such diversity as exists again be replaced by a single doctrine, perhaps even by the theory of optimal functioning of a socialist economy? The answer depends on the evolution of the USSR's political system in the future.

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Biology After Stalin: A Case Study

Mark B. Adams

STUDIES of Soviet science have tended to be focused either on aspects of policy or of content. "Policy" studies have dealt with the social dimension of scientific activity—the Academy of Sciences, its structure and reorganization; scientific manpower; resource allocation; administrative forms, procedures, and styles; the articulation of research priorities and goals; the interactions and balances between pure and applied research, technology and industry and the role of the Soviet government and the Communist Party in Soviet science. Such studies tend to use the approaches of political science, sociology, and economics and rely heavily on quantitative data, studies of structure and statements of policy.

By contrast, "content" studies have dealt with the nature and quality of Soviet scientific work in particular disciplines or problem areas (e.g. computer research, molecular biology, or elementary particle physics), estimating the significance and usefulness of theoretical and experimental results, comparing these results with work in the West and isolating key scientific innovators and thinkers. These studies have tended to put a premium on knowledge in one or several areas of science and rely on the analysis of scientific careers, the content of scientific articles and publications, and the importance of intellectual traditions.

This article uses both the "policy" and the "content" approaches. It deals with the development of research in molecular biology and genetics within the Soviet Academy of Sciences from roughly 1953 to 1965. This 12-year period begins with the death of Stalin and the formulation of the Watson-Crick double helix model for the structure of DNA, and ends with the ousting of N. S. Khrushchev and the re-establishment of the legitimacy of genetics and molecular biology in the Soviet Union. In political terms, it is roughly the period of Khrushchev's administration: in scientific terms, it is the period when genetics had an "underground" status in the Soviet Union.

Policy Conflicts in Biology

The August 1948 session of the Lenin All-Union Academy of Agricultural Sciences established the context within which Soviet policies concerning the biological sciences would be formulated for a decade and a half. The declaration of T. D. Lysenko (1898–1976) that the Central Committee had approved his position led directly to the delegitimization of genetics and its replacement by Lysenko's so-called

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"Michurinist biology." Lysenko's biology accepted the inheritance of acquired characteristics, supported a "saltationist" view of species formation, and laid heavy emphasis on the immediate agricultural benefits which could be derived from his principles. He denied the existence of genes, the general applicability of Mendel's laws and the chromosomal theory of inheritance, and the importance of Darwinian intraspecific competition. The August 1948 meeting led to recantations by a number of geneticists and to a Resolution of the Presidium of the Soviet Academy of Sciences which supported his position.[1]

It would be difficult to underestimate the damage to Soviet biology which resulted from these events. Although only two geneticists—Efroimson and Romashov—were arrested, virtually all Soviet geneticists lost their jobs and had to find employment elsewhere. Orbeli, a former student of Pavlov and one of Russia's leading physiologists, had supported the development of genetics as Academic Secretary of the Biological Sciences Division of the Academy of Sciences. In 1948, he was replaced by A. I. Oparin, a biochemist specializing in studies of the origin of life, and during Oparin's tenure (1948–56) Lysenko's policies held sway within the Biology Division of the Academy. Genetics had dominated two distinguished Academy institutes: the Institute of Histology, Cytology, and Embryology, formerly Kol'tsov's Institute of Experimental Biology, where Dubinin headed the genetics division; and the Severtsov Institute of Evolutionary Morphology, headed by Severtsov's star pupil, the evolutionary theorist I. I. Schmalhausen, best known in the West for his "theory of stabilizing selection." As a result of the decrees of 1948, these two institutes were amalgamated under G. K. Khrushchev's direction, the genetics laboratories were abolished, and Dubinin and Schmalhausen—two of the world's most accomplished evolutionary geneticists—lost their jobs. The curricula were changed in primary, secondary, and higher educational institutions to expunge genetics and incorporate Lysenko's views. The Lysenkoist curriculum was the basis of Soviet biological education until 1965.

Lysenko indicated in an interview in 1953 that Stalin had personally approved his position. Following Stalin's death in March 1953, it appeared for a time that official policy might shift away from Lysenko: articles critical of his views were published, Lysenko resigned as President of the Agriculture Academy, and Oparin was replaced as Academic Secretary of the Biological Sciences Division of the Academy of Sciences by V. A. Engel'gardt, a muscle biochemist and a strong supporter of genetics and molecular biology. However, such was not to be the case. Remarkably, Lysenko was able to win the support of

[1] *The Situation in Biological Science, Proceedings of the Lenin Academy of Agricultural Sciences of the USSR July 31–August 7, 1948* (complete stenographic record), (International Publishers: New York, 1949). See also: David Joravsky, *The Lysenko Affair* (Harvard University Press: Cambridge, 1970); Zhores A. Medvedev, *The Rise and Fall of T. D. Lysenko* (Columbia University Press: New York, 1969).

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Khrushchev. As Khrushchev's power over the Party and Government increased, so too did the official support for Lysenko's "Michurinist biology." Lysenko and Khrushchev seemed personally compatible: coming from similar Ukrainian villages, they portrayed themselves as "men of the soil," opposed by entrenched bureaucracies. Khrushchev's agricultural policy became more and more tied to Lysenko's theories and he would make much publicized visits to Lysenko's experimental farm at Lenin Hills. Indeed, during Khrushchev's administration, and especially after 1958, all policy statements on biology emanating from the Party or Government strongly supported Lysenko's position. Immediately following Khrushchev's ousting in October 1964, his support for Lysenko came under severe public attack. In 1965 and 1966, Soviet genetics regained its public legitimacy.

If we looked exclusively at official Party and Government policy statements concerning biology issued between 1948 and 1964, we might conclude that genetics and evolutionary theory were essentially "dead" in the Soviet Union. This would be a natural enough conclusion if we believed that the Soviet Academy was simply an instrument of the political authorities, and its policies are just passed down from above. In this case, however, such a conclusion would be false. Beginning in 1955, genetics and molecular biology research was conducted in a variety of institutional niches throughout the Academy system, by many of the same biologists who had been discredited and had lost their jobs in 1948.

Genetics research during this period was "underground" in a number of ways. It lacked official legitimacy: genetics was not taught in Soviet schools or supported in official policy statements—indeed it was often condemned. It hid under protective language: to cognoscenti, such terms as "radio-biology," "radiation bio-physics," and "physico-chemical biology" functioned as a kind of protective mimicry, serving as euphemisms for both orthodox genetics and molecular biology. Finally, it developed in a series of institutional settings under the aegis of the physical sciences, carefully isolated administratively from the influence and control of Lysenko's supporters.

It would be absurd to say that genetics prospered under such conditions. Nonetheless, research was supported, papers were published, graduate students were trained. Indeed, when genetics once again became legitimate in 1965 and 1966, Soviet geneticists began publication of the monthly journal *Genetika*—the world's largest genetics journal—and filled most of its pages with original Soviet research. A study of the contents of this journal during its first five years reveals that the six institutions responsible for the lion's share of the papers had all been established as centres of genetics research in the late 1950s.[2] What is most remarkable about the period 1956–64 is that

[2] *Genetika*, 1967, No. 7, pp. 144–146. The six institutions, and the number of articles which they contributed, were: Institute of Genetics AN SSSR (founded in 1965 around

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Soviet genetics was able to survive when the political atmosphere was so hostile to it.

Genetics could develop "underground" during this period largely because it had the protection and support of a powerful group of mathematicians, physicists, and chemists. Undoubtedly its most powerful supporter was the synthetic organic chemist A. N. Nesmeianov (1899–), who was excited by the implication of DNA work for his own field. Nesmeianov served as President of the Academy between 1951 and 1961, and in his many speeches before the Academy, the Central Committee, and Party Congresses, he called repeatedly for the urgent development of Soviet work in the physics and chemistry of life.[3] N. N. Semenov (1896–) was another powerful supporter of genetics. Director of the Institute of Chemical Physics since its creation in the early 1930s, Semenov won the Nobel Prize for Chemistry in 1956 for his work on chain reactions. Since 1950, he had sought in his own works to effect a "marriage between biology and chemistry," and as Secretary of the Chemistry Division of the Academy (1957–63), he was one of the prime movers behind the 1963 Academy reorganization, and subsequently as Vice-President of the Academy, he worked on behalf of the development of molecular genetics.[4] V. A. Engel'gardt (1894–) was one of the Soviet Union's leading biochemists, best known in the West for his demonstration in the late 1930s that myosin is contractile in the presence of ATP. As Academic Secretary of the Biology Division of the Academy (1956–59), and subsequently as director of the newly formed Institute of Radiation and Physico-Chemical Biology, Engel'gardt became the leading Soviet spokesman for molecular biology.[5] Other Soviet chemists who supported genetics include A. V. Topchiev (1907–62), a petroleum chemist who served as Secretary to the Presidium (1949–58) and as an Academy

Dubinin's laboratory in the Institute of Biophysics) (49); Institute of Cytology and Genetics, Siberian Division AN SSSR (36); Department of Genetics, Leningrad State University (36); I. V. Kurchatov Institutes of Atomic Energy AN SSSR (30); Gamaleia Institute of Epidemiology and Microbiology Academy of Medical Sciences (15); and Institute of Chemical Physics AN SSSR (13).

[3] The sources used for biographical information on Nesmeianov and most other Soviet scientists mentioned in this essay include the following: *Biographic Directory of the USSR* (Scarecrow Press Inc.: New York, 1958); *Biograficheskii slovar' deyatelei estestvoznaniya i tekniki*, 2 vols. (Moscow, 1959); *Who's Who in Soviet Space Science and Technology*, 2nd ed., compiled by Ina Telberg (Telberg Book Corp.: New York, 1964); *Who's Who in the USSR, 1965–1966*, 2nd ed., (ed.) A. I. Lebed, H. E. Schulz, S. S. Taylor (Scarecrow Press Inc.: New York, 1966); *Prominent Personalities in the USSR*, Institute for the study of the USSR, Munich, (ed.) E. L. Crowley, A. I. Lebed, H. E. Schulz (Scarecrow Press Inc.: Metuchen, New Jersey, 1968). For Nesmeianov, see also N. N. Semenov, "K 60-letiiu A. N. Nesmeianova," *Vestnik AN SSSR*, 1959, No. 9, pp. 23–26.

[4] "Akademik N. N. Semenov—laureat Nobelevskoi premii," *Vestnik AN SSSR*, 1956, No. 12, p. 101; "Nikolai Nikolaevich Semenov," *Genetika*, 1966, No. 4, p. 1; N. Semenov, "O vremeni i o sebe," *Nauka i zhizn'*, 1966, No. 6, pp. 16–21; *Nikolai Nikolaevich Semenov*, Materialy k biobibliografii uchenykh SSSR, AN SSSR, Seriya khimicheskaya, 2nd ed. enlarged (Nauka: Moscow, 1966), No. 38, 96 pp.

[5] *Vladimir Aleksandrovich Engel'gardt*, AN SSSR, Materialy k biobibliografii uchenykh SSSR, Seriya biokhimii, No. 4 (Izd. AN SSSR: Moscow, 1955).

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Vice-President (1958–62); I. L. Knuniants (1906–), winner of three Stalin Prizes for his work in developing synthetics; A. E. Braunshtein and M. V. Vol'kenshtein.

In addition, genetics received strong support from virtually the entire Soviet physics establishment. Unlike their colleagues in chemistry, Soviet physicists made few public statements on behalf of molecular genetics, apparently preferring to work behind the scenes in the decision-making councils of the Academy. Much of this support centred at the sacrosanct Institute of Atomic Energy, first directed by the "father of the Soviet A-bomb" I. V. Kurchatov and then by his successor A. P. Aleksandrov (now President of the Academy), both members of the Academy Presidium. Peter L. Kapitsa, a former student of Rutherford, enjoyed a rather special status as "grand old man" of Soviet physics, and during the period consistently used his regular private discussion group (*Kapishniki*), his membership on the Academy Presidium, and his access to political authorities on behalf of genetics. Other physicists who actively supported genetics include M. A. Leontovich, A. D. Sakharov (father of the Russian "H-bomb"), and especially I. E. Tamm (1958 Nobel Laureate in Physics).

These Soviet physicists shared a division of the Academy with the mathematicians, many of whom also strongly supported genetics. A. D. Aleksandrov worked on its behalf as Rector of Leningrad University and within the councils of the Communist Party, of which he was a member. The brilliant probability theorist A. N. Kolmogorov had published papers in population genetics in the 1930s. M. A. Lavrent'ev, an applied mathematician specializing in hydrodynamics, was the chief organizer of the *Akademgorodok*, and as Secretary of the Physics and Mathematics Division of the Academy, and subsequently of the Siberian Division, helped to develop genetics research under his administrative aegis. Lavrent'ev had been one of the leaders of Soviet computer work, and together with S. L. Sobolev and A. A. Liapunov, specialists in cybernetics and information theory and key figures in the organization of the Science City, he seemed fascinated by the concept of "biological information" and the DNA/RNA coding and transcription problem.[6]

Analyzing why these scientists supported genetics is beyond the scope of this discussion. For some, the Western work on DNA was close to their own disciplinary concerns: note that the majority of scientists were organic or biological chemists, cyberneticists, and nuclear physicists. A number had successfully defended their own disciplines against ideological attacks and may have wished to purge Soviet science of its most egregious example of political intrusion. My main point is that this group strongly opposed Lysenko and supported

[6] S. L. Sobolev, A. A. Liapunov, "Kibernetika i estestvoznanie," *Filosofskie problemy sovremennogo estestvoznaniya: Trudy Vsesoiuznogo soveshchaniya po filosofskim voprosam estestvoznaniya* (Izd. AN SSSR: Moscow, 1959), pp. 327–266.

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genetics, and that, as a group, they dominated Academy councils and constituted a substantial majority of the Academy's governing Presidium throughout the period 1956–64. They were the scientists responsible for formulating and articulating scientific priorities and policies during this period. Yet during this same period, official government policy opposed genetics and supported Lysenko. How were they able to act on behalf of genetics in the face of such opposition? An analysis of their efforts elucidates the relationship between Soviet science and Soviet science policy.

Strategies for Genetics

In order to understand the nature of the options open to the Soviet scientific leadership for supporting genetics, we must understand the Academy's structure.[7] Until 1963, the Academy of Sciences was organized into eight divisions, excluding the Siberian Division which we will discuss later. In addition to three divisions covering the humanities and social sciences, there were five concerned with science and technology: Physics and Mathematics, Chemistry, Biology, Geology and Geography, and Technology. Each of these divisions was directed by an Academic Secretary appointed by the Academy Presidium and approved by a vote of the General Assembly, which consisted of the total membership of the Academy and, according to its charter, held the ultimate authority in all Academy decisions. In actual practice, however, the Academy was administered by its Presidium, which consisted of the President, Secretary, and Vice-Presidents of the Academy, the Academic Secretaries of its various divisions, and a certain number of Academicians appointed " at large." While these 20 or so men largely controlled Academy policy, the divisions constituted the fundamental administrative units and had considerable control over their own internal functioning.

Within such a structure, the natural home base for Academy work in genetics and molecular biology would have been the Biology Division. However, despite repeated attempts by the Presidium to develop such research there, it met serious opposition and its efforts were largely unsuccessful. An analysis of its failure is instructive.

The Biology Division. In February 1956, the Presidium announced that A. I. Oparin was being relieved of his posts of Secretary of the Biology Division and member of the Presidium " at his own request," although Medvedev reports that this was a result of a petition signed by over 300 biologists.[8] His replacement was V. A. Engel'gardt, who immediately began to press for major changes within the division. At the Academy's annual meeting in March 1956, Nesmeianov complained

[7] *Ustavy Akademii nauk SSSR* (Nauka: Moscow, 1975).

[8] Zhores A. Medvedev, *The Rise and Fall of T. D. Lysenko*, trans. I. Michael Lerner (Columbia University Press: New York, 1969), p. 137.

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that " experimental biology has lagged behind " and commented: " We are preparing decisive measures along these lines and we hope for their success." [9] His remarks were elaborated in the speech of A. V. Topchiev, the Presidium's Chief Secretary: " The Biology Division must take urgent measures to liquidate the lag in several branches of genetics, cytology, and embryology." [10]

What " decisive measures " did Nesmeianov, Engel'gardt and the Presidium have in mind for the Biology Division? Various references are made in subsequent speeches to a " laboratory of radiobiology " in Leningrad, new " laboratories of cytology and genetics," a " virology institute," a " protein institute," and the reorganization of work in a host of institutes within the Biology Division. Due to resistance from members of the Biology Division, however, most of these projects never led to anything. Although the Presidium succeeded in establishing an Institute of Cytology in Leningrad in 1957 by expanding the Zoology Institute's laboratory of cytology, its distinguished director D. N. Nasonov died that same year and his successor, A. S. Troshin, never succeeded in developing the kind of cytogenetics work envisaged by the Presidium. The Presidium had more success in revamping the Institute of Biophysics, which had been established in 1952 under A. M. Kuzin's direction. This institute was severely criticized by the Presidium almost from the moment of its creation for " motley and haphazard " research planning, for " not coping with the tasks presented to it," and for failing to involve physicists in its planning and activities.[11] In early 1956, Kuzin was replaced as director by G. M. Frank, a supporter of genetics, and the institute established a large laboratory of radiation genetics under N. P. Dubinin, a Corresponding Member of the Academy and the only non-Lysenkoist geneticist in the Academy's membership at that time. A year later, Engel'gardt praised the creation of this laboratory, but noted that " the problems to which it is dedicated must become the subject of work in a strong, independent scientific institution." [12] However, such an institution was created, not in the Biology Division, but in the new Siberian Division, as we shall see.

Perhaps the most instructive example of the Presidium's difficulty was its attempt to create an institute of " radiation and physico-chemical biology " under Engel'gardt's direction. The Presidium's determination to create such an institute was announced by Nesmeianov in early 1956 and was reiterated at six-month intervals, more and more insistently, over the next four years.[13] One of the

[9] " Vstupitel'noe slovo prezidenta Akademii nauk SSSR akademika A. N. Nesmeianova," *Vestnik AN SSSR*, 1956, No. 3, p. 14.

[10] A. V. Topchiev, " Osnovnye itogi nauchnoi deyatel'nosti Akademii nauk SSSR za 1955 god," *Vestnik AN SSSR*, 1956, No. 4, p. 106.

[11] " O rabote Instituta biofiziki i o merakh po ee uluchsheniiu," *Vestnik AN SSSR*, 1955, No. 7, p. 102.

[12] " V Otdelenii biologicheskikh nauk," *Vestnik AN SSSR*, 1957, No. 3, p. 38.

[13] " Vyshe uroven' teoreticheskoi nauki," *Izvestiya AN SSSR, Seriya biologicheskaya*, 1956, No. 5, p. 6; A. N. Nesmeianov, " O zadachakh Akademii nauk SSSR v svete

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more curious references to it occurs in a resolution of the Presidium of 20 January 1959. In December 1958, the editors of *Botanical Journal* were criticized in *Pravda* and before the Central Committee for publishing articles critical of Lysenko. The response of the Academy was the 20 January resolution, signed by Nesmeianov, Topchiev, and Engel'gardt, which praised Michurinist biology, admitted mistakes, and outlined measures to correct its failings. After pages of self-criticism asserting the necessity for closer ties with agriculture, the resolution concludes with three cryptic sentences completely unrelated to the preceding text: these sentences state that it is "essential" to realize the Presidium's resolution of 1957 calling for the creation of an Institute of Radiation and Physico-Chemical Biology, state the necessity that physicists and chemists participate in its work, and call upon the Biology Division to present plans for an Institute of Virology.[14] This institute was actually founded only after Engel'gardt's replacement as Secretary of the Biology Division in March 1959 by N. M. Sisakian, a former Lysenkoist.[15]

Thus, after roughly four years as Secretary of the Biology Division, Engel'gardt had relatively little to show for his efforts. There is little doubt that much of the resistance to the Presidium's plans came from within the Biology Division. Much of this resistance can be explained by the fact that the division was Lysenko's stronghold in the Academy—which is not to suggest that most of its members were Lysenkoists of the same mettle as Lysenko himself, or of N. I. Nuzhdin, who had been elected to the Academy in 1953. But the division was filled with rather conservative biologists in traditional or practically oriented disciplines who had come to a compromise with Lysenko. This included biochemists such as A. I. Oparin, N. M. Sisakian, and A. L. Kursanov, whose work on plant metabolism could be made compatible with almost any theory of heredity[16]; microbiologists such as A. A. Imshenetskii who continued to believe in the inheritance of acquired characteristics in bacteria and who had serious doubts about

reshenii XX s"ezda KPSS" *Vestnik AN SSSR*, 1956, No. 6, p. 6; A. N. Nesmeianov, "Ob osnovnykh napravleniyakh v rabote Akademii nauk SSSR," *Vestnik AN SSSR*, 1957, No. 2, p. 27; "Ob organizatsii Instituta radiatsionnoi i fiziko-khimicheskoi biologii," *Vestnik AN SSSR*, 1957, No. 6, pp. 93–94; "O rabote komissii," *Vestnik AN SSSR*, 1958, No. 6, p. 100.

[14] "Khronika. O rabote i zadachakh Otdeleniya biologicheskikh nauk AN SSSR v svete reshenii dekabr'skogo Plenuma TsK KPSS: Postanovlenie rasshirennogo zasedaniya Prezidiuma Akademii nauk SSSR i Otdeleniya biologicheskikh nauk sovmestno s aktivom otdeleniya sostoyavshegosia 20 ianvarya 1959 g.," *Izvestiya AN SSSR, Seriya biologicheskaya*, 1959, No. 2, p. 318.

[15] "V Otdelenii biologicheskikh nauk," *Vestnik AN SSSR*, 1959, No. 5, p. 71; "Khronika: Obshchee sobranie Otdeleniya biologicheskikh nauk AN SSSR," *Izvestiya AN SSSR, Seriya biologicheskaya*, 1959, No. 4, p. 640; "Za ukreplenie svyazi biologii s praktikoi," *Vestnik AN SSSR*, 1959, No. 3 p. 7; "Ob Institute radiatsionnoi i fiziko-khimicheskoi biologii," *Vestnik AN SSSR*, 1959, No. 11, p. 110.

[16] *Aleksandr Ivanovich Oparin, AN* SSSR, Materialy k biobibliografii uchenykh SSSR, Seriya biokhimii, No. 6 (2nd ed.; Nauka: Moscow, 1964); uchenykh SSSR, Seriya biologicheskikh nauk, Biokhimiya, No. 5 (Nauka: Moscow, 1967).

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bacterial sexuality and the applicability of the chromosomal theory to his subject-matter[17]; and a host of Academicians—some 18 in number—who had been elected to the Academy in 1953 during the Lysenkoist heyday in such fields as soil science, ichthyology, entomology, paleontology, and botany.[18]

Such biologists tended to see the efforts of Engel'gardt and the Presidium on behalf of "physico-chemical biology" as an incursion by physicists, chemists, and mathematicians and a threat to the independence of biology and to their control over their own disciplines. These sentiments were clearly expressed in the discussions held in the Biology Division meetings during the period. When plans were first unveiled by the Presidium in early 1956 for "decisive measures" in support of "experimental biology," E. N. Pavlovskii (parasitology), P. A. Baranov (botany), Y. A. Orlov (paleontology) "and others objected to providing the experimental sciences with substantial material aid."[19] In the meeting of February 1957, Imshenetskii "expressed displeasure with the significant attention being given to the direction of our biological sciences by physicists, chemists, technologists, and mathematicians," arguing that "the fundamental problems of biology must be solved by biologists themselves." The ichthyologist G. V. Nikol'skii "accused physicists and chemists of the tendency to reduce biological laws to those of physics and chemistry" and he saw in the selective support of biochemistry and biophysics "a danger to the development of systematics, ecology, and morphology." The entomologist G. Ia. Bei-Bienko saw "a growing danger that the 'mother' sciences—botany and zoology—would be eaten up by their 'daughter' sciences."[20] Lysenko's arguments during the period were tailored to appeal to such fears of encroachment on biology by scientists in other fields.[21]

If the Biology Division made clear its opposition to the development of genetics and molecular biology within its ranks, the Presidium made it clear that "physico-chemical biology" was the only kind whose expansion it was willing to support. Thus, over the decade 1951–61, the Biology Division ranked fifth among the eight in terms of the rate of expansion in the number of its institutes, surpassing only Geology and Geography, and Literature and Language. More notably, during the same period, the number of scientific workers in the Biology

[17] *Aleksandr Aleksandrovich Imshenetskii*, AN SSR, Materialy k biobibliografii uchenykh SSSR (Nauka: Moscow, 1967); A. A. Imshenetskii, "Geneticheskii simpozium v Yaponii," *Vestnik AN SSSR*, 1957, No. 1, pp. 63–67.

[18] For an account of the 1953 elections, together with pictures, biographical sketches, and articles by the new members, see *Vestnik AN SSSR*, 1953, 1954, *passim*.

[19] "V Otdelenii biologicheskikh nauk," *Vestnik AN SSSR*, 1956, No. 4, p. 107.

[20] "Khronika: Obshchee sobranie Otdeleniya biologicheskikh nauk AN SSSR 6 fevralya 1957 g.," *Izvestiya AN SSSR, Seriya biologicheskaya*, 1957, No. 4, p. 390; "V Otdelenii biologicheskikh nauk," *Vestnik AN SSSR*, 1957, No. 3, p. 39.

[21] e.g., T. D. Lysenko, "K voprosu o vzaimootnosheniyakh biologii s khimiei i fizikoi," *Voprosy filosofii*, 1959, No. 10, pp. 103–105.

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Division grew more slowly than that of Chemistry, Physics and Mathematics, Technology, and the Siberian Division.[22]

The Presidium's influence was also felt in the elections to the Biology Division. Whereas the vacancies created in 1953 were slanted towards biologists in practical fields closely related to agriculture, forestry, and fisheries (technical microbiology, soil science, plant physiology, entomology, ichthyology) the nominees in 1958—though far fewer in number—were in keeping with the Presidium's policy: the two candidates for Corresponding Member of the Biology Division were A. N. Belozerskii (the most renowned Soviet researcher on DNA), and B. L. Astaurov, listed for purposes of election as a "cytologist," although in 1966 he became President of the newly formed genetics society. This policy was continued in the 1960 elections, which brought N. D. Ierusalimskii, M. N. Meisel', A. E. Braunshtein, A. M. Kuzin, G. M. Frank, and A. S. Troshin into the Academy in microbiology, biochemistry, radiobiology, biophysics, and cytology. So long as the Lysenkoists continued to enjoy political support from outside the Academy structure, however, such additions to the membership of the Biology Division were not sufficient to transform it into a supportive environment for the development of genetics and molecular biology.

Physical Science Divisions. In 1960, a year after he had resigned as head of the Biology Division, Engel'gardt was able to show some satisfaction in spite of his difficulties with its membership:

> . . . Until very recently we have seen the existence of some . . . insuperable barriers between institutions and activities of the Biology Division on the one hand, and the Divisions of the Physico-Mathematical and the Chemical Sciences on the other. Now we can already note the existence of such steps as the creation last year of the Institute of Radiation and Physico-Chemical Biology, and the fact that within the Chemical and Physico-Mathematical Sciences division, there have arisen new cells (*iacheiki*) of workers concerned with biological problems.[23]

Engel'gardt was alluding to the success that physical scientists had achieved in developing genetics and molecular biology within their own divisions.

If the efforts of the Academy's physical scientists to develop molecular biology and genetics within the Biology Division had met op-

[22] "Vstupitel'noe slovo academika A. N. Nesmeianova," *Vestnik AN SSSR*, 1961, No. 3, p. 6. Those with the highest rate of growth were the Technology Division (its number of institutes had increased by a factor of 4.3) and the Physico-Mathematical Division (3.6); the rate for the Biology Division was 1.4, although it must be noted that at the beginning of the period the Biology Division had the largest number of institutes. Budget figures of the various divisions, 1951–55, can be found in *Vestnik AN SSSR*, 1956, No. 3, p. 10. For the figures on numbers of scientific workers, see: A. V. Topchiev, "Our Scientific Cadres and the Training of New Talent," *Vestnik AN SSSR*, 1961, No. 12 (translated in *The Soviet Review: A Journal of Translations*, 1962, No. 5, pp. 3–21).

[23] "Obsuzhdenie otchetnogo doklada," *Vestnik AN SSSR*, 1960, No. 3, p. 91.

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position, little was encountered within their own divisions which, needless to say, were devoid of Lysenkoists. Within the Physics and Mathematics Division, the Kurchatov Institute of Atomic Energy established a large Radiobiology Section in 1955 where S. I. Alikhanian developed research in viral and microbial genetics. This institute not only became a leading Soviet centre of antibiotics research, but also served as a scientific forum where the latest results of Western work were discussed. As a leading centre of Soviet nuclear research, the Kurchatov Institute was held in high esteem and was well protected from Lysenkoist meddling: administratively, it reported to the bureau of the division, which in turn reported to the Academy Presidium, and both bodies were dominated by physical scientists who strongly supported genetics. The establishment of a biological division in such an institute was justified on the grounds that it studied the biological effects of radiation. Soviet physicists also alluded to the possibilities first posed by Schrödinger that studies of the mechanism of heredity might reveal new physical laws. Soviet physicists also participated in the planning and work of the Biophysics Institute where Dubinin's laboratory of radiation genetics had been founded in the same year, and most of its work was published, not by the Biology Division, but by *Atomizdat,* a publisher specializing in popularizing atomic physics and largely controlled by physicists.

Genetics also prospered in the Chemistry Division. After he became Secretary of the division in 1957, Semenov worked with such division chemists as I. L. Knuniants, M. M. Shemiakin, V. A. Kargin, M. V. Vol'kenshtein and S. E. Bresler to develop molecular biology and genetics within the division. Indeed, in 1958 Semenov established within his own Institute of Chemical Physics a laboratory for the study of chemical mutagenesis, headed by I. A. Rapoport, who had worked on the phenomenon in the 1930s. In Leningrad, a new Institute of Higher Molecular Compounds was established in the late 1950s under Bresler's direction where much research was conducted on nucleic acids, protein, and biosynthesis. Such work also developed in the division's Institute of Natural Compounds. Reports appearing in the division's journal show clearly that by 1961, a wide variety of research in molecular biology and genetics was being conducted in a host of chemistry institutes, and that a number of these institutes were coordinating their activities with the Radiobiology Section of the Kurchatov Institute. Chemists justified the inclusion of biological research into their division by emphasizing that the study of heredity had become in part a chemical problem, and that studies of the chemistry of proteins and especially nucleic acids held spectacular possibilities for the future of chemistry and the synthesis of chemicals. Once again, the development of such research within the Chemistry Division encountered no difficulty from Lysenkoists, since the division's bureau was full of

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supporters of genetics, and it in turn reported to the Academy Presidium.

The success of such efforts is apparent from an analysis of the articles published in *Genetika*, a Soviet genetics journal created in July 1965, during the first year and a half of its publication. During that period, it published 374 articles of original research written by authors in over 100 Soviet institutions, but six institutions were responsible for almost 50 per cent of the papers (179). The Kurchatov Institute of Atomic Energy contributed 30 papers published by *Genetika* and ranked fourth among institutional contributors. Semenov's Institute of Chemical Physics ranked sixth, contributing 13 articles. A number of other chemistry institutes also ranked high on the list.[24]

As we have seen, the Academy leadership employed a number of strategies designed to support genetics despite political opposition. There was relatively little difficulty in opening genetics laboratories within their own physics or chemistry institutes when such activity could be justified as "physics" or "chemistry." Within the physical science divisions, Lysenko's "territorial" arguments worked in favour of genetics: as he had often stated, physicists, chemists, and mathematicians were no more qualified to judge biological issues than was he to judge physics and chemistry.[25] Because of the structure and composition of the Biology Division, however, the Presidium was somewhat less successful in developing genetics and molecular biology within its ranks: their only success came when they were able to mandate the involvement of physical scientists in the affairs of especially suitable biological institutes—notably of Biophysics, Radiation and Physico-Chemical Biology.

Clearly, it would have been difficult to establish new institutes of genetics within a division of chemistry or physics and mathematics. Members of the Biology Division would have seen through this subterfuge and could have argued effectively—and with some justice—that this was an attempt to encroach upon their field of expertise and usurp their legitimate prerogatives: here territorial arguments would surely have won the day, given the political support that Lysenko was able to muster. There remained, however, the option of reorganization and, as we shall presently see, the leadership used this to create a new and vigorous institute of genetics.

The Effects of Academy Reorganizations

During the decade 1955–65, the Soviet Academy of Sciences underwent three major reorganizations—in 1957, 1961, and 1963. Although

[24] *Genetika*, 1967, No. 7, pp. 144–146.

[25] For example, T. D. Lysenko, "K voprosu o vzaimootnosheniyakh biologii s khimiei i fizikoi," *Voprosy filosofii*, 1959, No. 10, pp. 103–105; "Za materializm v biologii," *Voprosy filosofii*, 1958, No. 2.

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three reorganizations in six years may appear somewhat extraordinary, the Soviet Academy was by no means unique among Soviet institutions in this respect. Indeed, one of the hallmarks of Khrushchev's administration was the frequent reorganization of Soviet bureaucracies, including the Ministry of Agriculture, the nation's economic management, and so forth. Khrushchev's distrust of bureaucrats and dislike for "red-tape" (*kantselyarshchina*) was great during this period, and the subject of frequent comments and asides which he made at Central Committee meetings, in publicly reported speeches, and in private conversations. Lysenko had made appeal to Khrushchev's anti-bureaucratic biases by portraying himself as a simple and dedicated innovator opposed in the Academy by an entrenched scientific establishment: indeed, this may have been one of the reasons for Khrushchev's growing support of him in the late 1950s. But other scientists could—and did—appeal to those same biases when it served their purposes. And one of their purposes was the re-establishment of Soviet genetics.

The discussions and planning that went into Academy reorganization gave the Soviet scientific leadership many opportunities for the more or less covert support of genetic research. The 1957 reorganization, which established *Akademgorodok*—the Science City in Novosibirsk—and a separate, interdisciplinary Siberian Division of the Academy, resulted from the initiative of M. A. Lavrent'ev, S. L. Sobolev, and S. A. Khristianovich, the first two being applied mathematicians involved in computer research who strongly supported genetics. The 1963 reorganization, which replaced the eight former divisions with fifteen aggregated into three major new sections, was preceded by widespread discussions in which N. N. Semenov was one of the most active participants, and the plan finally adopted clearly bore his mark. As we might expect, both reorganizations opened broad possibilities for the development of genetics and molecular biology.

In understanding how Soviet science policy is formulated and administered, and what effects it has on the actual conduct of scientific research, the reorganizations of 1957 and 1963 are especially instructive. It is natural enough that no contemporary Western account of these organizations emphasized their impact on Soviet genetics: most public discussions and justifications for these reorganizations in the Soviet Union made no mention of it. Only in discussions within the Academy and its publications is genetics mentioned—and even these references almost disappear after 1959. Yet both reorganizations made it possible for genetics and molecular biology to develop in newly established institutes which were clearly—and I would argue deliberately—isolated from Lysenkoist control and interference.

1957: Akademgorodok and the Siberian Division. The 1957 Academy reorganization was the result of an idea by M. M. Lavrent'ev and S. L. Sobolev. An applied mathematician, Lavrent'ev had been the director (1950–53) of the Institute of Precision Mechanics and

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Computing Technology, where he had overseen the construction of the first Soviet computers—apparently with Khrushchev's help. According to his own accounts, Lavrent'ev went directly to Khrushchev with his idea, and received his approval to travel to Novosibirsk in either late 1956 or early 1957 to select a site for the research complex and coordinate his efforts with the local Party authorities.[26]

Lavrent'ev's suggestion could hardly have come at a more politically auspicious time. Khrushchev was preparing a project to decentralize the administration of the Soviet economy and thereby hopefully to stimulate the economic, industrial, and agricultural development of Siberia.[27] Lavrent'ev's plan fitted perfectly with such a policy: an interdisciplinary complex of research institutes was to be built in the heart of Siberia and geared to its economic needs, to be administered by a new, interdisciplinary "Siberian" division of the Academy. A new university was to be created, to be administered, not by the Ministry of Education, but by the Academy itself to discover and train the young scientific talent of Siberia. In his more extravagant moments, Lavrent'ev even suggested that it might be possible to thaw the Siberian tundra and turn it into a giant new agricultural area. In view of the fact that traditionally Soviet science had been concentrated around Leningrad and Moscow, with more than 75 per cent of its scientists located in those regions,[28] the scientific community's willingness to move many of its numbers to Siberia must have given the impression that it could hardly have been more cooperative. The coordination of the reorganization with Khrushchev's economic decentralization is supported by the dating of the relevant decrees: the industrial reorganization was passed by the Supreme Soviet on 10 May 1957; the Siberian Division of the Academy was created by a decree of the Council of Ministers on 18 May, roughly a week later.[29]

[26] On the Science City, see: "Novyi nauchnyi tsentr na Vostoke. Beseda c prezidentom Akademii nauk SSSR akademikom A. N. Nesmeianovom," *Pravda*, 8 June 1957, p. 3; I. P. Bardin, "Rastushchie nauchnye tsentry strany," *Vestnik AN SSSR*, 1957, No. 8, pp. 3–14; A. V. Topchiev, "Stroitel'stvo Kommunizma i nauka," *Kommunist*, 1957, No. 13, p. 83; "Ob ispolnyaiushchem obyazannosti vitse-prezidenta Akademii nauk SSSR," *Vestnik AN SSSR*, 1957, No. 9, p. 102; "Sozdanie krupnogo nauchnogo tsentra v Sibiri. Na obshchem sobranii Akademii nauk SSSR," *Vestnik AN SSSR*, 1957, No. 12, p. 14; M. A. Lavrent'ev, "Razvitie nauki v Sibiri i na Dal'nem Vostoke," *Vestnik AN SSSR*, 1957, No. 12, pp. 4–7; M. A. Lavrent'ev and A. K. Chernenko, "Razvitie nauki v Sibiri," *Vestnik AN SSSR*, 1959, No. 1, pp. 66; and M. Lavrent'ev "Vstrechi s uchenymi," *Nauka i zhizn'*, 1964, No. 4, pp. 10–12.

[27] "Zakon o dal'neishem sovershenstvovanii organizatsii upravleniia promyshlennost'iu i stroitel'stvom," *Resheniya Partii i Pravitel'stva po khozyaistvennym voprosam*, Vol. 4, 1953–61 (IPL: Moscow, 1968), pp. 343–347.

[28] N. K. Khrushchev, *Pravda*, March 30, 1957, p. 4; E. A. Beliaev, "Geografiya sovetskoi nauki," *Vestnik AN SSSR*, 1967, No. 10, pp. 27–34; "Soviet's Union's 'Academic Cities' Symbolize New Efforts in Scientific Research," *New York Times*, 16 Oct, 1967.

[29] "Postanovlenie Soveta Ministrov SSSR o sozdannii sibirskogo otdeleniya Akademii nauk SSSR," *Resheniya Partii i Pravitel'stva po khozyaistvennym voprosam*, Vol. 4, 1953–1961 (IPL: Moscow, 1968), pp. 347–349; on the relation, see "The perfection of the administration of industry and the tasks of scientists," *Vestnik AN SSSR*, 1957, No. 4, pp. 3–6.

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Although Khrushchev would hail the founding of the Science City as a "patriotic act" on the part of Soviet scientists, it also clearly served the interests of the scientific community and the Academy in important ways. Clearly the establishment of a genetics institute was not the only motive. At a time when cybernetics and computer research were coming out from under an ideological cloud and becoming an increasingly important concern, the hub of the new complex was to be a computer centre which was to serve all the institutes, even though under the control of the Institute of Mathematics and its director, S. L. Sobolev. *De facto* if not *de jure*, the Science City became a haven for renegade fields whose development was not receiving its proper scope in the traditional capitals of Russian science—fields like mathematical linguistics, econometrics, as well as cybernetics—and for scientists like V. S. Nemchinov, an agricultural statistician and economist, and L. V. Kantorovich, an econometrician who helped develop input-output analysis and who won the Nobel Prize in 1975. Interdisciplinary by design, the complex was able to develop fields of research located at the borders of more traditional disciplines.

But clearly the Academy leadership looked upon the development of the Science City as a way to expand the Academy's researches in genetics. They emphasized this obliquely in their discussions in 1958 of the Siberian Division. Nesmeianov emphasized that it would play an important role in the Academy's plans to develop physico-chemical biology, and his remarks were elaborated by Topchiev:

> The absence of the necessary experimental base for investigations in biochemistry, biophysics, microbiology, radiogenetics, neurophysiology and several other branches of biology is still a rather serious constraint on the development of all scientific directions in biology. . . .The Siberian Division . . . is being called upon to play a most prominent role in increasing the level and scope of these investigations.[30]

In his remarks, Engel'gardt noted that, despite improvements in institutes within the Biology Division, their position was nonetheless "unsatisfactory" and commented that "only after broadening the experimental base of old institutes and creating new biological institutions, especially in Siberia, will it be possible to achieve a rapid upsurge in Soviet biology.[31]

There is no doubt that Nesmeianov, Topchiev, and Engel'gardt had genetics in mind. The government decree which established the Science City had left the selection of institutes and their directors and staff to the Presidium of the Academy and an organizational committee. The earliest list of institutes included an Institute of Cytology and Genetics,

[30] "Osnovnye itogi nauchnoi deyatel'nosti Akademii nauk SSSR za 1957 god. Doklad glavnogo uchenogo sekretarya Prezidiuma Akademii nauk SSSR akademika A. V. Topchieva," *Vestnik AN SSSR*, 1958, No. 5, p. 21.

[31] "Prenya po otchetnomu dokladu," *Vestnik AN SSSR*, 1958, No. 5, p. 30.

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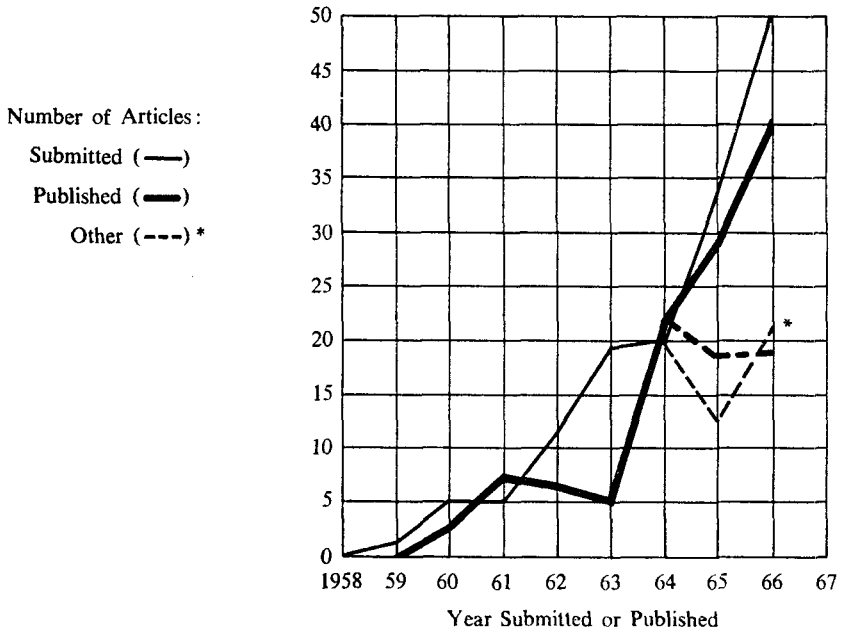
Figure 1

PUBLICATION DATA: INSTITUTE OF CYTOLOGY AND GENETICS, SO AN SSSR



EXPLANATION: The graph indicates articles prepared by authors identifying themselves as working at the Institute of Cytology and Genetics, Siberian Division (SO), AN SSSR, and submitted for publication and/or published in *Izvestiya SO AN SSSR*, (1958–66) or *Genetika* (1965–66). These two journals account for most of the work published by members of the Institute.

*Since *Genetika* was created in July 1965, the figures for 1965 and 1966 marked by the unbroken lines indicate the sum of articles in the two journals; figures for *Izvestiya's* part of that total are indicated by broken lines.

Data on submission dates was arrived at by examining all relevant articles published in *Izvestiya* and in *Genetika* up to 1967. These dates were included on all articles publishing original research in genetics, and were omitted only on review and historical articles which are therefore not tabulated in the submission data.

Izvestiya sibirskogo otdeleniya AN SSSR replaced *Izvestiya vostochnykh filialov AN SSSR* at the beginning of 1958; its biological series was published three times annually (Nos. 4, 8, & 12). *Genetika* has published monthly since July 1965, although articles were submitted to it for publication as early as April 1965.

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to be headed by N. P. Dubinin, a distinguished geneticist and longtime foe of Lysenko. The inclusion of this institute with Dubinin as its director was confirmed by a general meeting of the Academy on 2 November 1957, and Dubinin was the only biologist included on the Scientific Council of the Siberian Division, appointed in mid-1957, and on its Presidium, confirmed in mid-1958.[32] This Scientific Council had been given the duty of planning the institutes and, in particular, had been granted "during the organizational period the right to appoint directors of laboratories, departments, sections, and senior scientific associates of the newly created institutes (without announcing a competition)."[33] Thus freed from the normal administrative procedures for appointing personnel, the institute directors had virtually a free hand in staffing their institutes, and Dubinin used this authority to appoint geneticists, some of whom had not been able to work in genetics for a decade, including P. K. Shkvarnikov, V. V. Khvostova, N. A. Plokhinskii, I. I. Kerkis, Z. S. Nikoro, and D. K. Beliaev, who was appointed the Assistant Director of the institute.

Genetics was able to develop vigorously in the Science City. An analysis of the submission of genetics articles by the institute's staff and their subsequent publication between 1959 and 1966 shows the steady increase in its output of genetics research, a conclusion reinforced by a study of the dates of experimentation given in a number of articles published in *Genetika* by the institute staff beginning in 1965 (see fig. 1). An examination of the content of these articles indicates that from 1958 on, research was proceeding on a host of topics, including radiation and chemical mutagenesis, protein synthesis, DNA replication and RNA synthesis, chromosomal structure, biometrics, population genetics, polyploidy in wheat, corn, sugar beets and other plants, and epistatic interaction of colour genes in mink.

In addition, the institute's staff formed the faculty of the Department of Genetics of the newly formed Novosibirsk State University. Because the university was administered entirely by the Academy's Siberian Division, it was able to teach genetics freely in the early 1960s, unhampered by the Ministry of Education. Indeed, the Division also ran a special secondary school which was limited to Siberian students who passed a special competitive examination, the "Olympiada." Run by S. Literat and A. A. Liapunov, this school taught genetics as part of its ninth grade biology course beginning in the 1962–63 academic year, and the course syllabus became the basis of ninth-grade biology teaching in Siberia beginning in 1965.[34]

[32] "O Sibirskom otdelenii Adademii nauk SSSR," *Vestnik AN SSSR*, 1957, No. 9, p. 102; "O prezidiume Sibirskogo otdeleniya," *Vestnik AN SSSR*, 1958, No. 7, p. 114.

[33] *Vestnik AN SSSR*, 1957, No. 9, p. 102.

[34] S. L. Sobolev, "Uchit' myslit'," *Literaturnaya gazeta*, 26 June 1962; M. A. Lavrent'ev, "Vam, N'iutony atomnogo veka," *Komsomol'skaya pravda*, 12 November 1964, p. 1; see the articles by B. Kh. Sokolovskaya and Iu. Sokolovskii in *Uchitel'skaya gazeta*, 22 December 1964 and 16 September 1965 and in *Biologiya v shkole*, 1966, No 1 p. 71.

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Thanks to the interdisciplinary nature of the Science City, the Institute of Cytology and Genetics enjoyed close working relationships with other institutes of the complex: jointly with the Mathematics Institute, it published a number of works elaborating cybernetic approaches to biology, and its laboratory of nucleic acids cooperated with that of N. Knorre, who was working on messenger RNA and the genetic code within the Institute of Organic Chemistry. But a far more important effect of the Siberian Division's interdisciplinary character was the protection it afforded genetics from Lysenkoist interference. Dubinin's institute was directly responsible to the Presidium of the Division, a Presidium dominated by physical scientists sympathetic to genetics—indeed, for a time he was the only member who was a biologist. This Presidium in turn reported to the Academy's Presidium, once again dominated by physical scientists sympathetic to genetics. The geneticists did not even have to submit their work for publication to biological journals: it was published in the biological sciences issues of the *Vestnik* of the Siberian Division, whose editorial board was again dominated by physical scientists. As we shall see, these administrative arrangements were to prove very important indeed. Thus was created what many even today regard as the best centre of genetics research in the Soviet Union.

1963: Reorganization and the Pushchino Complex. As we have seen, N. N. Semenov was a strong supporter of genetics, and he was an active participant in the discussions of the organization of scientific research which took place between 1959 and 1963. In August 1959, he proposed that the eight divisions of the Academy be reduced to three: "a division of experimental sciences (mechanics, physics, chemistry, experimental biology); a division of geological and geographical sciences (geology, geography, descriptive biology—fauna, flora, ethnography, i.e. the study of nature, natural resources, and population); and a division of social sciences (philosophy, economics, history, language studies)." [35] Note that this organization would have put experimental biology and genetics in a division with the physical sciences, separated from descriptive biology.

When technologists in the Academy, notably I. P. Bardin, objected to Semenov's downgrading of technology and his proposed relegation of technological institutes to industry, Semenov revised his position and included a technical division in the Academy which would, however, be concerned with pure rather than applied research. In his revised plan of January 1960, Semenov continued to argue strongly for an Academy devoted to an interdisciplinary attack on fundamental theoretical and experimental problem areas, and once again highlighted biology, remarking that "the time has come to bring biological problems right to the fore." He objected strenuously, however, to a proposal to

[35] N. Semenov, "Nauka segodnya i zavtra," *Izvestiya*, 9 Aug. 1959, p. 3.

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establish a series of discipline-centred academies, arguing that "all the more interesting problems are found on the borders" of the sciences and that "the Academy of Sciences must be one and indivisible." [36]

The implication of Semenov's plans for genetics, of which he must have been fully aware, should be noted. In view of the difficulties which the Presidium had encountered with the Biology Division, a discipline-centred academy for biology was the last thing he wanted. If genetics and molecular biology were to develop, it would have to be with the support of physical scientists, preferably in a division with them separated from Lysenkoists and traditionalists, and failing that, at the very least in the same Academy with them, "one and indivisible," where physical scientists could continue to have some control over biology.

In the overall Academy reorganization of 1963, Semenov got much of what he wanted. Although the number of divisions was increased to 15, they were organized into three Sections: "Physico-Technical and Mathematical Sciences," "Chemico-Technical and Biological Sciences," and "Social Sciences." Semenov became a Vice-President of the Academy and head of the Chemico-Technical and Biological Sciences Section. This Section consisted of five divisions: two chemical, two biological (Physiology, and General Biology), and a fifth division which represented the "marriage between biology and chemistry" which he had sought: the Division of Biochemistry, Biophysics, and the Chemistry of Physiologically Active Compounds. This division included, from the former Chemistry Division, the Institutes of Natural Compounds, Higher Molecular Compounds, and Physiologically Active Compounds, and from the former Biology Division, the Institutes of Cytology, Microbiology, Biophysics, Biochemistry, Animal Morphology, and Radiation and Physico-Chemical Biology.[37] The preponderance of biological institutes reveals the degree to which the reorganization constituted a way of separating them from Lysenko's influence: his own Institute of Genetics became part of the General Biology Division. It should be noted that, as Vice-President of the Academy in charge of this section, Semenov became the director of the biology divisions as well as the chemistry divisions.

This reorganization also made possible the establishment of a "science city" for the biological sciences at Pushchino, a small town on the Oka river near Moscow. Plans for this centre had been announced by Nesmeianov as early as 1956 when he noted that the Presidium was planning "the construction of a complex of biological

[36] *Izvestiya*, 7 and 8 Jan. 1960.

[37] These institutes represent virtually all those in the two divisions where research on genetics and molecular biology was taking place. On the 1963 reorganization, see the discussion in *Vestnik AN SSSR*, 1963, No. 6. For a sketchy account in English, see James M. Swanson, "Reorganization: 1963," *The State of Soviet Science* (M.I.T. Press: Cambridge, Mass., 1965), pp. 36–40.

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institutes." [38] The next year, Engel'gardt confirmed that plans were "being made to equip buildings as biological institutes in Pushchino on the Oka." [39] In 1958, however, Nesmeianov noted that the Presidium's plans were encountering difficulties:

> Our very serious and well-founded efforts to resolve the cardinal problem of an experimental base for biologists in Moscow has thus far not met with success. The construction of a science city at Pushchino south of Serpukhov—one of the fundamental goals of which is the development of biochemistry, biophysics, microbiology, and the chemistry of natural compounds—is thus far in a state of moratorium.[40]

Later that year, in an article in *Pravda*, he defined the science city at Novosibirsk as concentrating mainly on physico-technical specialties, whereas the one planned for Pushchino was to be a complex of institutes devoted to "physico-chemical biology." [41] In 1961, he noted that construction had begun on the Biophysics Institute.[42] Finally, in June 1962, it was announced that the complex of institutes had finally been approved: this Presidium announcement criticized the institutes of the Biology Division for "not answering the growing demands made of biological science at the present time," noted that "all institutes equipped at Pushchino must work on current problems of biology with wide use of the achievements of physics and chemistry," and listed the institutes to be included (General Virology, Microbiology, Biophysics, Chemistry and Natural Compounds, Plant Physiology, and Animal Biochemistry).[43]

Considering that plans for the Pushchino complex were announced at roughly the same time as those for the Novosibirsk Science City, and that its establishment was a top priority of the Presidium, we may wonder why it was only established during the period 1963–67. The delay is reminiscent of the one in founding Engel'gardt's institute, and the reason is undoubtedly related: prior to 1963, the Pushchino complex would have fallen under the direction of the Biology Division where resistance was strong. Following the 1963 reorganization, however, it was put under the new Division of Biochemistry, Biophysics, and Chemistry of Physiologically Active Substances and developed rapidly and without further difficulty. G. M. Frank was the first director of the Pushchino complex, and his Institute of Biophysics was the first to move there from Moscow—the same institute which

[38] A. N. Nesmeianov, "O zadachakh Akademii nauk SSSR v svete reshenii XX s"ezda KPSS," *Vestnik Akademii nauk SSSR*, 1956, No. 6, p. 6.
[39] "V Otdelenii biologicheskikh nauk," *Vestnik AN SSSR*, 1957, No. 3, pp. 102–103.
[40] "Vstupitel'naya rech' prezidenta Akademii nauk SSSR akademika A. N. Nesmeianov," *Vestnik AN SSSR*, 1958, No. 5, p. 7.
[41] A. N. Nesmeianov, *Pravda*, 1 December 1958, pp. 2–3.
[42] "Vstupitel'noe slovo akademika A. N. Nesmeianova," *Vestnik AN SSSR*, 1961, No. 3, p. 7.
[43] "O stroitel'stve biologicheskikh institutov v Pushchino," *Vestnik AN SSSR*, 1962, No. 6, p. 101.

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contained Dubinin's laboratory of radiogenetics. Subsequently three other institutes were established: an Institute of the Biochemistry and Physiology of Microorganisms (directed by N. O. Ierusalemskii and, after his death, G. K. Skriabin), an Institute of Photosynthesis (directed by V. B. Evstigneev), and finally, in 1967, an Institute of Protein (directed by A. S. Spirin).

Thus both the 1957 reorganization and the 1963 reorganization had great consequences for the development of Soviet molecular biology and genetics. Both created suitable administrative contexts where genetics was isolated from Lysenkoists and traditional biologists and linked with chemists, physicists, and mathematicians, creating vertical lines of authority which excluded opponents of genetics from any administrative involvement in its development. That these arrangements were both necessary and effective can be seen by the ineffectiveness of Lysenko's various attempts at political intervention.

Academy Resistance to Political Intrusion

The Academy Presidium made several attempts to oversee and criticize the work of Lysenko's institute and to dislodge him: these attempts were usually aborted as the result of political instructions. Conversely, Lysenko and his followers made several attempts to uproot the pockets of genetics research which were proliferating throughout the Academy structure. Remarkably, these efforts were also unsuccessful, for reasons that are worth exploring—especially since Lysenko had Khrushchev's support in these efforts. Let us consider the outcome of four such attempts.

(1) We have already noted the events which led to Engel'gardt's replacement as Secretary of the Biology Division in March 1959, after only three years in office. In December of the preceding year, *Pravda* had criticized Engel'gardt, Nesmeianov, the Biology Division, and the Academy Presidium for failing to link its work closely enough with practical agricultural needs, and for permitting its journals to criticize Lysenko openly. At a special joint meeting of the Presidium and the Biology Division on 20 January 1959, these groups passed a resolution admitting their failings and mistakes. They detailed plans for improving ties with agricultural needs, and for supporting Michurinist biology, but nonetheless urged the establishment of an institute for Engel'gardt and another in virology.[44] This resolution was undoubtedly in preparation for the 21st Party Congress which met a week later, from 27 January–5 February 1959. In their speeches before the Congress, Lysenko strongly criticized the failings of the Biology Division, but Nesmeianov and Semenov emphasized the importance of developing studies in the chemistry and physics of life. The Congress resolution, while supporting Lysenko, nonetheless included the following sentence

[44] See footnote 14, above.

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taken from Nesmeianov's speech: "The significance of the complex of biological sciences will grow especially as does the use of the achievements of physics and chemistry within biology." [45] The editorial in the Academy's journal for March 1959 continued this approach: although strongly affirming the necessity of increasing work in agriculture, it strongly affirmed also the importance of physico-chemical biology.[46] Within a month, it was announced that Engel'gardt was "laying down the responsibility of being Academic Secretary of the Biology Division in connection with the expiration of his term" (although originally no term had been specified), and his fellow biochemist N. M. Sisakian, a former Lysenko supporter, was appointed to replace him.[47] In the subsequent three or four years, there was little if any criticism of Lysenko in Academy publications.

Despite Lysenko's success in stilling criticism and in replacing Engel'gardt, he did not succeed in altering the Presidium's determination to support genetics. From Lysenko's point of view, Sisakian must have appeared an ideal choice to head the Biology Division, since he had been a vociferous advocate of Lysenko's theories and Michurinist biology, and had sought to demonstrate their efficacy in studying the biochemistry of metabolism in a series of publications in the period 1948–54.[48] But as the new Secretary of the Biology Division, Sisakian changed his tune: his first major speech reiterated support for the very same policies which Engel'gardt and the Presidium had advocated for the preceding three years. Nesmeianov and the Presidium continued strongly to support "physico-chemical biology" in their speeches and writings. After years of delay, the Institute of Radiation and Physico-Chemical Biology was established under Engel'gardt's direction. The nature and timing of these events suggests that the scientific leadership had come to a kind of compromise with Lysenko's political supporters: in exchange for stilling public criticism of Lysenko, they would be able to develop their kind of biology.

(2) The establishment of the Institute of Cytology and Genetics in the new Science City under Dubinin's direction did not escape the attention of Lysenkoists. In his general discussion of the Science City before the Central Committee in June 1959, Khrushchev singled out Dubinin for criticism:

> We must take care that in the new science centres people are selected who are able to move science forward, who render by their work the necessary assistance to production. It is known, for

[45] *Vneocherednoi XXI s'ezd Kommunisticheskoi Partii Sovetskogo Soiuza*, Vol. II, (GIPL: Moscow, 1959), p. 534.

[46] "Za ukreplenie svyazi biologii s praktikoi," *Vestnik AN SSSR*, 1960, No. 5.

[47] "V Otdelenii biologicheskikh nauk," *Vestnik AN SSSR*, 1959, No. 5, p. 71; "Khronika: Obshchee sobranie Otdeleniya biologicheskikh nauk AN SSSR," *Izvestiya AN SSSR, Seriya biologicheskaya*, 1959, No. 4, p. 640.

[48] "See, for example, N. M. Sisakian, *Biokhimiya obmena veshchestv* (AN SSSR: Moscow, 1954); see also his essay in *Problemy biokhimii v Michurinskoi biologii* (Izd. AN SSSR: Moscow-Leningrad, 1949).

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> example, that in Novosibirsk an institute of cytology and genetics is being built of which the biologist Dubinin was named director, an opponent of Michurinist biology. If Dubinin is known for anything, it is by his articles and speeches against the theoretical positions and practical recommendations of Academician Lysenko.
>
> I do not wish to be the judge between trends in the work of these scientists. As is known, practice is the judge. But practice speaks in defence of the biological school of Michurin and Lysenko, who continues his work. Take, for example, the Lenin Prizes. Who received Lenin Prizes for selection?—Scientists of the materialist trend in biology, from the school of Timiriazev, from the school of Michurin, from the school of Lysenko. Where are the outstanding works of the biologist Dubinin, who is one of the chief organizers of the fight against the Michurinist views of Lysenko? If he did not bring forth anything of real use working in Moscow, he will hardly do so in Novosibirsk or Vladivostok.[49]

This attack resulted in Dubinin's resignation in late 1959, although according to one account he had the support of both M. A. Lavrent'ev and the Party organization.[50] The announcement of his release in January 1960 indicated that D. K. Beliaev had been named as Dubinin's temporary replacement, and he has remained director ever since.

Perhaps the most interesting aspect of Dubinin's resignation is that it had no effect whatever on the staffing, organization or research of the Institute of Cytology and Genetics, or on its growth as a leading Soviet centre of genetics teaching and research. Beliaev, the new director, had been Dubinin's hand-picked assistant. At the time of Dubinin's resignation, the laboratory directors and staff of the institute had already been appointed and were working; no changes were made in this staff as a result of his resignation. The only change occasioned by Dubinin's resignation that I know of concerns the institute's work as contained in Lavrent'ev's accounts: in early 1959, before Khrushchev's attack, he emphasized theoretical questions and used the words " genetics " and " heredity," whereas in his next account in 1961 he dropped these two words altogether and emphasized those results relevant to agriculture. As is revealed by a study of the publications of the institute, however, this change in description did not reflect any change in the nature, quality, or rate of growth of its genetics work. If anything, Dubinin's resignation may have benefited the institute by giving it a less controversial director.

(3) A. N. Nesmeianov became President of the Academy in 1951 upon the death of the physicist S. I. Vavilov. As we have seen, he supported genetics from the earliest years of his tenure, and this support became increasingly evident, vehement, and explicit after

[49] " Rech' tov. Khrushcheva, N. S.," *Plenum TsKKPSS*, 24–29 June 1959 (Gosizdat: Moscow, 1959), pp. 465–467.

[50] " V. Prezidiume," *Vestnik AN SSSR*, 1960, No. 1, p. 91; V. Gubarev, *Komsomol'skaya Pravda*, 27 February 1965.

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1957. Lysenko had become increasingly critical of Nesmeianov after Khrushchev's purge of the "anti-Party" group, and in 1960 and early 1961, when Nesmeianov had become politically vulnerable on other grounds, Lysenko's criticisms of him in Central Committee meetings and the press reached a crescendo, becoming increasingly confident, lengthy, and condemnatory. These criticisms almost certainly played some role in Nesmeianov's premature resignation as President of the Academy in early 1961. His replacement as President was M. V. Keldysh, a specialist in aerodynamics who had played a role in the Soviet space programme. If Lysenko had imagined that an aerodynamist would be less attentive to biology than an organic chemist, he was mistaken. In his first major policy statement as President, made barely a week after he took office, Keldysh reiterated almost verbatim the policy towards biology which Nesmeianov and the Presidium had been supporting for years.

(4) The reorganization of 1963, together with events in the preceding two years, had brought molecular genetics increasingly into public attention. In 1961, the International Congress of Biochemistry was held in Moscow. At this meeting, Nirenberg announced his first success in breaking the genetic code, an event that even optimistic Soviet scientists such as Engel'gardt had not anticipated for 50 years.[51] In a special meeting of the Presidium in early 1962, a Commission on Molecular Biology was created under Engel'gardt's direction with wide powers of translation, publication, and review over the work of various institutes. The spate of popular articles on these breakthroughs put Lysenko's supporters on the defensive.

Academy elections were scheduled for June 1964. At Khrushchev's initiative, the government created an unprecedented number of vacancies in genetics—three full and two corresponding memberships. The chief nominees for these posts were two practical breeders—Luk'ianenko and Pustovoit—and Lysenko's vociferous supporter, N. I. Nuzhdin, who had been elected a Corresponding Member in 1953, together with the Lysenkoist Remeslo. The new Division of General Biology took the unusual step of rejecting Remeslo. However, the 1963 reorganization had separated institutes concerned with physico-chemical biology from this division and helped to create the conditions which led to its approval of Nuzhdin's candidacy. This decision was, however, subject to review by the entire Academy membership in the General Assembly. In an event almost without precedent in Soviet history, after a stormy debate the Academy membership rejected Nuzhdin by a vote of roughly 126 to 20.[52]

According to Medvedev's account Khrushchev reacted sharply to

[51] M. Vasil'ev and S. Gushchev, *Reportazh iz XXI veka* (Izd. Sovetskaya Rossiya: Moscow, 1958), pp. 75–76.

[52] Zhores A. Medvedev, *The Rise and Fall of T. D. Lysenko* (Columbia University Press: New York, 1969), pp. 214–220.

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the Academy's action, demanding explanations from the Academy President and others who had participated in the debate, accusing the Academy of " entering politics," and establishing a commission to look into the possibility of abolishing the Academy and reconstituting it as a " Committee on Science." He also created a series of plenipotentiary commissions to review the work of biological institutes, and put Lysenko and his followers on those reviewing institutes where genetics work had developed most actively. It is difficult to know how the Academy might have defended itself, or what role it played in the events of 12–14 October 1964 when Khrushchev was relieved of his posts. Even before Khrushchev's ousting was publicly announced, press articles were commissioned and began to appear—written by geneticists and critical of Khrushchev for his support of Lysenko. These events led to the re-establishment of genetics in 1965.

These four episodes show an interesting pattern of repetition. In each case, Lysenko called upon the support of Khrushchev to overturn the biology policy of the Academy Presidium. In the first three cases, criticism centred on certain personnel in key posts not subject to legitimate Lysenkoist administrative control—Engel'gardt, Dubinin, Nesmeianov. In each case, the offending person resigned. Yet, in each case, these resignations did not reverse the policies which they had advocated: the policies of Engel'gardt, Dubinin, and Nesmeianov were continued by their replacements, Sisakian, Beliaev, and Keldysh. The fourth case is somewhat different, in that it was an attempt to add Lysenkoists to the General Biology Division of the Academy to secure it as a Lysenkoist stronghold. This attempt failed because physical scientists and other supporters in the General Assembly refused to ratify the election of such members—although, interestingly enough, that same election brought into the Academy a classical geneticist with impeccable credentials, D. K. Beliaev, as a member of the Siberian Division in " biology and physiology."

The fact that Lysenko felt it necessary to call upon Khrushchev's intervention, and the further fact that such interventions were largely ineffective in uprooting genetics, are tributes to the success of the strategies employed by the Academy leadership. Meeting resistance to their efforts from within the Biology Division, they used and created opportunities to set up centres of genetics research outside of Lysenkoist control within physical science institutes, and within newly organized Academy divisions dominated and controlled by physical scientists. These events also have important implications for the study of Soviet science policy.

Implications for the Study of Soviet Science Policy

The study of recent history is a vital prerequisite to any attempt to plot future trends and permits us to draw on many sources of data and information which allow us to formulate a more complex picture

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than would be possible if we studied only the current situation, or very recent events. Such an ahistorical approach would present us with a static picture, and no sense of the underlying historical continuities, patterns, and trends which is necessary in order to foresee how the situation might develop in the long run. The historical approach not only permits us to see beyond individual events to the groups of actors and their long-range goals: in addition, it permits the study of the consequences of various actions, policies, and strategies, and to perceive the evolving interactions and trade-offs between alternative courses of action.

This article has dealt with the development of biology and the policies regarding it during the period from 1953 to 1965. Many changes have occurred in Soviet science and the Academy since this period. Many members of the older leadership group have retired and have been replaced by a later generation of administrators. The political situation with regard to science has changed several times. Science policy itself has become a separate subject of study in the Soviet Union (contained within the new discipline "*naukovedenie*"). Nonetheless, the current system of Soviet biological research was set into place by the events described here, and current Soviet biology has been profoundly affected by its Lysenkoist past and the efforts to overcome it. Studies of the current state and the future of Soviet biology must reckon with the fact that the generation of students educated in the 1940s and particularly the 1950s were trained in Lysenkoism, producing virtually a missing generation in Soviet biology. As the new younger generation of biologists trained since the mid- and late 1960s comes increasingly to the fore, they will both suffer and benefit from the lack of a preceding generation. Today, the development of Soviet biology continues to be marked by the effects of its divisional reorganization and its new institutional foundations, which we have examined. The "interdisciplinary" ideology institutionalized in Novosibirsk and Pushchino continues to have its effects on the flow of information between biological disciplines, and between biology and other fields, as well as on the self-conceptions of biologists and the selection of problem areas for research. In addition, Lysenkoists continue to occupy posts and have influence.

But the implications of this study go beyond Soviet biology. In Western studies, the Soviet Academy of Sciences is sometimes portrayed as an administrative arm of the government, centralized and controlled so as to do its bidding more effectively. However, the picture of the Soviet scientific community which emerges from this study is rather different. The 1950s witnessed a resurgent Soviet Academy whose activities were vital to the Soviet government in innumerable ways, including computers, missiles and nuclear weapons, and the Academy used the power and leverage it thereby gained to increase its autonomy and control over the conduct of science and to serve the

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vital interests of the Soviet scientific community. Far from being passive administrators of politically determined science policies, the leadership of the Academy was active and opportunistic in creating policies and organizational forms which they perceived to be in the interests of Soviet science. As we have seen, while paying lip-service to government policies with regard to biology, they were capable of formulating their own policies—in some important respects at variance with the government's—and capable of implementing them in subtle, sophisticated, and, on occasion, covert ways.

Nor are recent events at variance with this picture. The Academy leadership sought to assert its right to decide scientific matters and to exclude politics from scientific discussions. The emerging relationship between the Academy and the government was one of symbiosis, not submission: politics would be left to politicians, science to scientists, and each group would provide the other with things vital to their mutual existence. From the government, science would receive the necessary material support; from science, the government would receive its military and economic benefits. It is no wonder, then, that when political petitions were passed around the Science City, as they were at various times for Medvedev, Sakharov, and others, a common reaction was: "Don't rock the boat." The severe political difficulties encountered by many Soviet scientists in recent years have almost never stemmed from their scientific work, but from their political views and writings. It was Zhores Medvedev's books on politics, not on biology, which got him into trouble, and the same is true of Sakharov. Nor should we be surprised to find many Soviet scientists who had risked political difficulties to defend genetics now signing petitions against Sakharov: scientists speaking on political matters threaten to undo the symbiotic relationship predicated on the separation of science and politics, and invite the kind of political interference in science which led to the Lysenko problem in the first place.

This study of the Academy's science policy and the picture of the Soviet scientific leadership which emerges from it has several methodological implications for future Western studies of Soviet science policy. (1) General statements of science policy issued by the government or the Academy do not always represent the real policy being administered within the Academy, and hence must be read with great care. Very often, statements made by the scientific leadership in less formal contexts, ranging from speeches at Academy meetings to popular articles, give a clearer picture of the actual policies. (2) Soviet scientists tend to be sensitive to the implications of various general policies for their own fields and the development of lines of research within them, and those studying such policies should be equally sensitive to such implications. Since the real implications for the actual conduct of research are often not clearly and accurately stated in policy discussions, it is vital to study and keep track of the actual

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research papers emerging from various disciplines in order to perceive the real effects of policy on the conduct of science. (3) Changes in the organization of the Academy can have many subtle effects on the conduct of science, some deliberate, some unintended. Different classifications of knowledge and the divisional structures which they entail change lines of accountability and authority, the power of certain disciplines and groups over others, and thus ultimately the character of research which will be supported. (4) Finally, changes in key personnel, even when these changes result from political interference, do not necessarily mean changes in policy. As we have seen, changes in personnel can and have resulted in the removal of controversial figures so that the policy which they have supported can proceed without further difficulties.

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Soviet Technology: The Case of Single Cell Protein

Arthur E. Humphrey

IN the early 1960s, an increasing demand for animal protein by the Soviet population (roughly 3 per cent per year) began rapidly to outstrip the Soviet agricultural cereal grain production (increasing at only 2 per cent per year). Moreover Soviet animal feed technology in the 1960s could not be compared with that of the Western world. For example while farmers in the USA were obtaining one pound of beef for every eight to nine pounds of feed, the Soviets obtained only one pound of beef for every 15 pounds of feed. The difference was due largely to the fact that the US supplemented feed with protein. This 10–15 per cent feed supplement, primarily with soya meal protein, enabled US farmers to achieve high feed efficiency. In contrast, Soviet farmers had to depend on cereal grains for the necessary feed protein.

Recognizing a potential crisis in Soviet cereal grain production as a result of consumer demand for meat, the USSR Council of Ministers stimulated research in 1960 for new sources of protein to be added to animal feeds. The annual production of two million tons of protein for supplementing feed to be achieved in the ninth five-year plan (1971–75) was set as a goal by the Council of Ministers.

Various sources of protein were considered. These included: leaf, fish meal, oil seed meal, and single cell protein (SCP).

Of these various alternatives, only SCP, i.e. the growth of single cell micro-organisms rich in protein, such as yeast and bacteria on various substrates, was felt to be a viable alternative for the Soviet economy. Two primary substrates were chosen for internal development. These were wood waste hydrolyzates and n-alkane fraction of crude oil.

The reasons for these choices were rather obvious. The Soviet Union has the largest forested area of any nation in the world; hence it has a great potential for the production of wood hydrolyzates from its lumber industry. Also, as far back as 1960 several experts attached to the Council of Ministers, such as A. Z. Yakovenko, talked of "energy farming" and utilizing the hydrolyzates of vegetable material as a basic raw material in the food and chemical industry.

In 1960 this approach was considered to be very backward because most Western countries were evolving a chemical economy based on petroleum. Few had the foresight to predict the energy crisis then. Apparently, there was a debate at that time in the Council of Ministers because an alternative project for developing SCP from crude oil fractions was initiated. It is likely that fortuitous circumstances rather than great insight into long-range planning may have been responsible for the two alternative projects.

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Thus, in 1960 the discovery of the vast Volga-Ural fields led the Soviet planners to predict that the USSR had the potential for becoming the major crude oil producer in the world—a prediction which came true in 1975. Furthermore, since the high n-alkane (waxy) composition of crude oil from these regions made it difficult to pump and handle, dewaxing the crude oil i.e. removing the n-alkane fraction, could make the crude oil more valuable in the world market. Fortunately for Soviet planners, micro-organisms utilize only the n-alkane fraction of the crude oil. Hence, the possibility of microbial dewaxing of crude oil and the need for the production of single cell protein came together at the same time.

Up to this time the microbiological industry had been one of the lesser industries. It was based on the relatively backward technology of utilizing molasses and sulphite waste liquid for the production of fodder yeast, baker's yeast, industrial alcohol, acetic acid (vinegar), and solvents such as acetone, isopropanol, and butanol. The organisms utilized in these processes were primarily yeasts of the genus *Saccharomyces* and the genus *Candida.* Again, this state of affairs was to prove beneficial to the Soviets. These two genera have proven to be the most satisfactory micro-organisms for rapid development of a safe SCP. Thus, a rather backward Soviet microbiology community was poised for easy transition to SCP work.

IN 1966 V. D. Belayev was appointed head of the Main Administration for the Microbiological Industry (*Glavnoe upravlenie mikrobiologicheskoi promyshlennosti*). The microbiological industry was given greater resources and higher priorities than the others. A new institute, the All-Union Scientific Research Institute for Protein Synthesis, was established in Moscow under the Main Administration, with primary focus on production of SCP from crude oil fractions. In addition, the Main Administration was given the responsibility for overseeing the All-Union Hydrolysis Agency (*Gidrolizprom*) and its associated research institute, the All-Union Scientific Research Institute for Hydrolysis (Leningrad). Research emphasis at the latter institute was shifted from producing alcohol, carbonic acid, and furfurol out of hydrolyzed materials such as wood and agricultural wastes to producing SCP from these same wastes. Again the shift of emphasis was rather timely because more economical and efficient processes for the production of ethyl and butyl alcohol from ethylene were being constructed in the Soviet petrochemical industry. It was a relatively easy job to convert the anaerobic alcohol processes to aerobic SCP processes.

In 1960 most Soviet hydrolysis plants were geared to the production of 6–20,000 tons per year of sugar as a syrup which would yield 3–10,000 tons per year of alcohol. By converting the fermenter to an aerobic system and expanding the filtration and drying sections, these

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same plants could produce as much as 3–10,000 tons per year of fodder yeast. Since 1976 the All-Union Hydrolysis Agency has 43 operating hydrolosis plants; these utilize mostly wood waste as the primary substrate, and produce nearly 450,00 tons per year of fodder yeast.

A 70,000 tons per year fodder yeast plant was built in 1973–74 and construction was begun in Bashkiria and Volgograd of two 120–240,000 tons per year fodder plants, scheduled for completion in 1976. During the tenth five-year plan an annual production of more than 1,000,000 tons per year of fodder yeast from hydrolyzates is to be achieved.

Research for the production of SCP from petroleum fractions was begun in 1960 at the Institute for the Biochemistry and Physiology of Micro-organisms under Academician N. D. Ierusalimskii. Three scientists, G. K. Skryabin (now head of the Institute and the Acting Chief Scientific Secretary of the USSR Academy of Sciences), V. K. Eroshin, and A. B. Losinov, developed a n-alkane process utilizing a yeast, *Candida guilliermondii.* They received the Lenin Prize for their accomplishments. It might be noted that the Soviets claim that the theoretical principles for single cell protein production were developed in the USSR in the 1920s; they cite specifically a paper done by T. A. Tauson in 1926. The latter carried out research on alkane-utilizing micro-organisms prior to Dworkin and Forster in 1954–56. However, the work of Dworkin and Forster is generally accepted as the first significant achievement in this area.

The first experimental Soviet plant (1,500 tons per year capacity) for producing SCP from petroleum was put into operation in 1964 in Krasnodar. This plant operated on gas-oil. Nutritional studies were instigated in cooperation with A. A. Pokrovsky, Head of the Institute for Nutrition in Moscow. It was quickly realized that there were toxicological problems when impure gas-oil was used as the substrate. A second production plant was built in 1958 with a production capacity of 12,000 tons per year utilizing rectified 99 per cent pure n-alkane.[1] (This material had a molecular range of C_{14} to C_{20}).

The nutritional results with the product of the second plant were extremely good. As a consequence, large scale plant construction was begun at Ufa (100,000 tons per year) in 1968, at Gorky (100,000 tons per year initially and later expanded to 200,000 tons per year) in 1970, and at Kirishi near Leningrad (100,000 tons per year) in 1972.

[1] In connection with SCP production, it should be noted that at the 7th World Petroleum Congress in Mexico in 1967, S. V. Chepigo, Director of the All-Union Institute of Protein Synthesis, claimed that the Soviets had SCP plants with 50 cubic metre fermenters. However, in a report presented at the PAG Symposium in Brussels, March 1976, E. R. Shenderei, First Deputy Chief of the Main Administration for Microbiology Industry, stated that the first major Soviet SCP plant was not built until 1968. Obviously, Chepigo was talking about planned and not actual fermenters. In dealing with the Soviets, one is frequently presented with information on capabilities which later turn out to refer to planned rather than actual production or capacity. Because there is some chance that the statements in the Soviet reports refer to planned goals rather than actual facts, care has been taken in this paper to interpret all figures appropriately.

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Currently Soviet SCP production from hydrocarbons is estimated at 430,000 tons per year; the total fodder yeast from both petroleum and hydrolyzate may exceed 880,000 tons per year. Obviously, the Soviets are well on the way to achieving their objective of 2,000,000 tons per year by 1980.

The Krasnodar plant, with an output of 12,000 tons per year, was equipped with air-lift type fermenters. Operating experience showed that they failed to obtain the necessary mass transfer characteristics and, consequently, also failed to achieve the productivity and economy desired for large scale plants. Similarly, an SCP yield of only between 80–100 per cent was achieved. Intensive research was then initiated at the All-Union Institute for Protein Synthesis in Moscow to improve the strain of *Candida guilliermondii*. The following specific improvements are expected: growth rate of 0·3 to 0·4 $hr.^{-1}$; biomass yields of up to 120 per cent, containing 60–65 per cent crude protein; and oxygen transfer rates sufficient to sustain 5kg biomass per cubic metre of working volume per hour. P. I. Nikolyov of the Institute of Chemical Machine Design in Moscow was asked to design new fermenters for installation in the modified Gorky plant. S. Yenikeyev of the Department of Chemical Cybernetics at the Institute for Chemical Technology in Kazan contributed to the design of the plant control for the optimization of the SCP process.

ON the surface it would appear that the Soviet SCP processes are developing most rapidly. Indeed, in September 1975, E. R. Shenderei predicted that the Soviet SCP process based on n-alkane feedstock would be perfected to a point which would permit the USSR to offer the SCP process for external licensing in spring of 1976. However, this has not come to pass. On the contrary, the Soviets have made inquiries to Union Carbide about their mole sieve process for making pure n-alkane. This suggests that there may be problems with the n-alkane substrate obtained by distillation. Also, the Soviet design of SCP fermenters is most unusual. The Soviets have also addressed themselves to an Austrian firm, Vogelbusch, which by USSR'S own admission has developed a fermenter with excellent oxygen transfer capability. This is somewhat curious because it is highly doubtful that Vogelbusch fermenters are capable of achieving the 5kg of biomass per cubic metre per hour on hydrocarbon feeds already claimed by the Soviets. Again there is a suggestion that the 5kg of biomass per cubic metre per hour is only a *planned*, not an achieved capacity. Such oxygen transfer capacity is at the high end of the capability of western-designed fermentation equipment.[2]

[2] In 1974 the Soviets spent over $1,000,000 on a highly instrumented computer-coupled fermenter system, constructed in the US for the All-Union Institute of Protein Synthesis. There was an indication that the Soviets expected this equipment to allow them to optimize their SCP process. At last report (December 1975), this system was not fully operable, largely due to the lack of sufficient Soviet expertise in computer programming and in instrumentation repair at the Institute.

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The Soviets have made virtually no outside contact with the Western world regarding the SCP hydrolyzate process. This might be due to self-sufficiency because of a major breakthrough in the hydrolyzate process. But such a qualitative breakthrough is highly unlikely because the Soviets have been reasonably open in discussing the details of the process when queried. Indeed, knowledgeable US process engineers feel that the Soviet process is not significantly different from that developed by the US Department of Agriculture during World War II.

It is difficult to know what the real state of the Soviet SCP production is. Most certainly the demand by the Soviet citizenry for meat protein has produced great pressure for achieving rapidly a 1–2 million tons per year capacity for SCP production. With respect to SCP produced from petroleum, it is likely that the discovery of large Soviet petroleum reserves and the high waxy character of these reserves has made it reasonable to produce, at least in the short term, SCP from petroleum fractions. The fact that the Soviets have yet to construct an additional 1,100,000 tons per year plant capacity to achieve their 1980 goal of 2,000,000 tons per year of SCP indicates that the complete technology is not yet in place. However, it is evident that the Council of Ministers has placed high priority on this task so that we may expect the machinery to accomplish this task will soon be brought into being.

It is highly likely that the Soviets will view this effort as a demonstration of successful planning and technology transfer. This author tends to believe that the Soviet achievements are due, in part, to a convergence of events that set the stage for the necessary development. This view, however, should not detract from the idea that the USSR's achievements will ultimately be extremely important to the supply of meat protein available to the Soviet citizenry. Such achievements will help the Soviets to conserve their own grain supply, and this, in turn, implies that the world's grain supplies will stretch a little further.

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How Science Policy is Formed

John Turkevich

Introduction

During the last half century science and technology have played a dominant role in political and economic affairs. The development of the atomic bomb changed the nature of warfare, making all-out war suicidal. Then the discovery of missiles and rockets made the whole world vulnerable to attack. The increased dependence of the standard of living on per capita available energy has forced technology to turn from coal to petroleum. The availability of this high-grade energy to satisfy the increasing demand of all sectors of the world society for an ever-increasing standard of living has made new demands on science and technology. On the other hand the interaction between peoples has made the world smaller and more interdependent. Ease of communication with radio and television has led to increased awareness of a better life and greater economic and social mobility. This coupled with ease of transportation, with the automobile and the aeroplane, has led to greater geographic mobility of persons, with weakening of cultural distinctions and appearance of a uniform pattern in the mode of living.

The discoveries of science and the developments of technology have been the major cause of these developments. This has been recognized explicitly during the last 30 years, and the leaders of the major powers have increased their desire to consider the effects of future scientific discoveries.

There are three motivations for the leadership of any country. The first and most dominant is the safeguarding of the external security of the country—in our specific case, military research. While this was present in World War I with emphasis on poison gas warfare, tanks, and aeroplanes, it reached its zenth in the research of World War II: atomic bombs, radar, military aircraft, and missiles, and it has continued unabated since that time. It should not be forgotten that these purely military devices had important peaceful consequences: nuclear power plants, laser and solid state electronics, jet commercial planes, space exploration, to name but some. Since World War II there has been a conscious effort to utilize existing knowledge for military purposes both defensive and offensive. The results have been the nuclear weapons race, the missile race, the development of aeroplanes and tanks and of methods of destruction of all of these. This is the main motivation, the main expenditure of funds and the top priority in personnel in the Soviet Union. While a considerable amount of scientific and technical work in the Soviet Union is pedestrian and shoddy, the planning, organization, implementation and development in the military area

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is first-class, whether it is done by the engineer corps of the army or the scientific technical groups of the internal security forces.

The second important responsibility of leaders of any country and certainly of the Soviet leadership is the economic welfare of the people: producing the food, housing and clothing for daily living against the background of knowledge that the Soviet people have of better conditions in the countries of the West. The leadership, to retain its control, must provide, at least, bread. They must be cognizant of the fact that the revolution of 1917 was started by food riots in Petrograd, that Khrushchev fell because of food shortages in 1963, and that Gomulka fell in 1970 because of the Baltic coast food riots. This is exacerbated by the inability of Soviet agriculture to guarantee a crop sufficient to feed the country because the amount of the crop varies with annual climatic conditions. Superimposed on that are the inefficiencies of the small farms, the lack of economic incentives, the lack of fertilizers and pesticides, and the flight of manpower from the villages to the city. There is also evidence of a steady temperature decrease in the northern agricultural regions, reducing their areas of production. In addition to satisfying the main bulk of the population with food and clothing, the government and the party must satisfy the ever-rising demands of the intelligentsia—the scientists, engineers, party and government officials, managers of enterprises, teachers, doctors—in fact all professionals—for a higher and higher standard of living: television sets, electrical appliances, high quality food, cars. For a specific and a characteristic example: in recent years the scrawny Russian chicken has been replaced occasionally on the market by a juicy French imported chicken. The planners must make a decision on whether manpower and monies should be allocated to capital investment with long-range yield or for short-term consumer goods, and on how much science and technology can be obtained from the West and how much can be developed internally. The development of new processes, however, is a very expensive operation. In the first place, it is estimated that, in the United States, a dollar spent on research requires 10 dollars on development of the process and 100 dollars for working out the production. Furthermore, research is very expensive, costing about 80,000 dollars a year per man. A research project, to have viability, must have a budget of at least half a million (six man years). Only then has it a chance to be really successful. Also not all research projects are worth developing. Further, in many of the modern processes, capital investment is the dominant cost. This is why Soviet leaders are anxious in their science and technology planning to obtain complete processes from the West on the one hand, and capital as loans to buy these processes on the other. Thus the motivation to satisfy the economy (though slightly less important than military considerations) plays a highly significant role in preserving, through economic well-being, the group in power, and also serves as underpinning for the military effort.

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Another important motivation, particularly for scientific activity, are the desires of the individual scientists to further their own intellectual interests in their field and to satisfy their curiosity. This is well illustrated by a Soviet story told by the late Academician Artzimovich, a leading nuclear physicist. It was common during the Khrushchev era for Radio Tbilisi (Soviet Georgia) to ask "stupid" questions and for Radio Yerevan (Armenia) to give "clever" answers. For example, Radio Tbilisi would ask Radio Yerevan, "What is scientific research?" and Radio Yerevan, after a pause, would answer "as far as we can determine, scientific research is satisfying personal curiosity at government expense." Thus, in formulating scientific policy, this aspect of intellectual activity is highly important. For it was this type of intellectual activity that has led to the major industrial processes that are the basis of our economic life. Science policy must guarantee that this sector of society is viable and must furnish its resources to be effective in its unpredictable search for unexpected but significant discoveries.

Thus the science policy of any major country, and particularly of the Soviet Union, must be formulated to satisfy three objectives—military security, the economic well-being of the country, and finally the intellectual curiosity of individual scientists. These three objectives, while clearly delineated, are still interrelated. While they are common to many nations, the mechanism of their attainment, the formulation of the science policy for these objectives and the implementation have national characteristics which differ from country to country.

Formulation of Soviet Science Policy

In the Soviet Union, there is a gap between policy formulation and policy execution. The former is the prerogative of the Communist Party while the latter is the responsibility of the government. This should not be understood to mean that the Party does not take part in the implementation and the government does not assist in planning. There are cross lines between the two—organizationally and through key persons holding dominant positions in both Party and government.

The various organs involved in science policy formulation are the First Secretary of the Party, the Politburo of the Central Committee, the Central Committee itself, the Committee on Science and Educational Institutions of the Central Committee, the State Committee on Science and Technology of the Council of Ministers, the State Planning Committee (*Gosplan*), the Presidium of the USSR Academy of Sciences, the various ministries (e.g. Defence, Medium Machine Construction, Atomic Energy, Chemistry, Petroleum).

Let us first consider the first secretary, Leonid Il'yich Brezhnev (1906–). For the last 13 years he has been dominant in the Soviet Union. He has had a metallurgical training in Dneprodzerzhinsk and was associated with the space effort, being the top member of the

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Party to deal with that enterprise. He has consequently a detailed and intimate knowledge of the importance of science and technology and of formulating science policy. He is a very able technocrat.

The ruling group in the Soviet Union is the Politburo of the Central Committee of the Communist Party, which in turn is selected by the Central Committee of the Communist Party. Of the 15 members the following are technocrats: Full members: L. I. Brezhnev; V. V. Grishin (1914–), graduated from Moscow Geodesic Institute; A. P. Kirilenko (1906–), graduated from Rybinsk Aviation Institution; A. N. Kosygin (1904–), graduated from Leningrad Textile Institute; D. A. Kunaev (1912–), graduated from Moscow Institute of Non-Ferrous Metals and Gold, Doctor of Technical Sciences, President of Kazakh Academy of Sciences (1952–55); K. T. Mazurov (1914–), graduated from Gomel Autohighway Technekium; until recently, N. V. Podgorny (1903–), graduated from Kiev Technological Institute of Food Industry; V. V. Shcherbitzki (1918–), graduated from Dnepropetrovsk Chemical Engineering Institute; D. F. Ustinov (1908–), graduated from Leningrad Military-Mechanical Institute; and Candidate Members: Yu. V. Andropov (1914–), graduated from Marine Transportation Institute; P. N. Demichev (1918–), graduated from Mendeleev Chemical Engineering Institute in Moscow; and M. S. Solomentsev (1913–), graduated from Leningrad Polytechnical Institute.

The next in importance in policy formulation is the section for Science and Educational Facilities of the Central Committee of the Communist Party. This is known as the "apparatus" of the Party. Its members are the active staff members who execute policy studies and carry out the detailed work which the Politburo needs for its decisions and the Central Committee for its discussions. This committee is a training place for important Soviet science and education administrators. M. A. Prokofiev (1910–), the Minister of Education, was its chairman, as was V. A. Kirillin (1913–), the deputy Prime Minister and Chairman of the State Committee for Science and Technology of the Council of Ministers. The present chairman is Sergei P. Trapeznikov, who succeeded N. F. Krasnov in 1965. Sergei G. Shcherbakov is one of three deputy chairmen. The head of an extensive secretariat is Aleksander V. Michurin. The Central Committee also has a number of "instructors" supervising a given "sector" of scientific or educational activity.

Mikhail Alexseevich Prokofiev (1910–) is a member of the Central Committee of the Communist Party elected by the 24th Congress in 1971. He has been a member of the Party since 1941. He graduated from Moscow University in 1935. He received a doctorate in chemical sciences, is a professor and corresponding member of the Academy of Sciences (1967). From 1935 to 1937 and from 1941 to 1946 he was in the Soviet army. From 1946 to 1948, senior research associate and deputy director of the Institute of Chemistry of Moscow University.

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From 1948 to 1951, senior research associate and secretary of the Party Committee of Moscow University. From 1951–66, deputy head, head of the main administration of the Ministry of Higher Education of the USSR and the USSR Ministry of Culture, Deputy Minister of Higher Education (1954–59), and Specialized Secondary Education of the USSR (1959–66). From December 1966, Minister of Education of the USSR Deputy of the Supreme Soviet of the Seventh and Eighth Assemblies.

Vladimir Alekseevich Kirillin (1913–) is a member of the Central Committee, elected by the 24th Party Congress in 1971. He has been a member of the Communist Party since 1937. He graduated from the Moscow Energetics Institute in 1936. He has the degree of Doctor of Technical Sciences and the rank of professor. He has been an Academician of the USSR Academy of Sciences since 1962. From 1938–41 and from 1943–54, he was teaching, carrying out research and party work at the Moscow Energetics Institute. In 1941–43 in the Soviet Navy. In 1954–55, deputy Minister of Higher Education of the USSR. In 1955 deputy President of the State Committee on New Technology of the Council of Ministers. From 1955–63, in the apparatus of the Central Committee of the Party as head of the Section on Science and Educational Institutions. Vice-President of the USSR Academy of Sciences. From 1965, deputy Prime Minister of the USSR and Chairman of the State Committee of the Council of Ministers of the USSR on Science and Technology. From 1963–66, chairman of the administration of the All-Union Society *Znanie,* Laureate of State Prize (1951) and Lenin Prize (1959). From 1956 to 1961, he was a member of the Central Control Committee of the Party, and from 1961–66, candidate member of the Central Committee. Deputy of the Supreme Soviet of the Sixth, Seventh and Eighth Assemblies, co-author of *Basic Experimental Thermodynamics* (1950), *Thermodynamic Properties of Gases* (1953), *Thermodynamics of Solutions* (1956), *Investigations of Thermodynamic Properties of Substances* (1963), *Heavy Water* (1963), and *Technical Thermodynamics* (seventh ed., 1968).

Sergei Pavlovich Trapeznikov (1912–), member of the Central Committee elected by the 24th Party Congress. Member of the Party since 1931. Graduated in 1946 from the Moscow Pedagogical Institute as an extra-mural student, and the Higher Party School of the Central Committee. A 1948 graduate of the Academy of Social Studies at the Central Committee, Doctor of Historical Sciences and a professor, he began work as a hired hand on a *kulak* farm. In 1929–34, he was engaged in Komsomol work in the Middle Volga region; in 1935–44 in Party work in Penza oblast, in charge of food production; second secretary Vadinsk regional Party Committee; first secretary Narochatsk and Serdobsk regional Party Committees; director of agricultural section of Penza oblast Party Committee. In 1948–56, director of Higher Party School of Central Committee of Moldavia. In 1956–60, in the apparatus of the Central Committee of the USSR. In 1960–65, deputy rector in charge of scholarly work in the Higher Party School. From

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May 1965, head of the Section on Science and Education Institutions of the Central Committee. Deputy of Supreme Soviet of the Seventh and Eighth Assemblies.

Other departments that undoubtedly contribute to science policy formulation are those of the defence industry, heavy industry, and the chemical industry. Available information about the activities of the Apparatus of the Central Committee is very limited. A number of prominent scientists act as advisers and consultants.

Another important department of the Central Committee is the Commission of Popular Control (before December 1965 known as the Party and State Control Commission). Through its branches in Republics and regions, this committee serves as a "watchdog" of errors and misapplication of Party directives. Important posts in the scientific and education establishments are placed on the *nomenclatura* list, and nominees require prior approval by the Central Committee of the Party or its branches before these posts can be filled. This list includes the directors of important research institutes, leaders of sectors, and deans of universities.

The Central Committee of the Communist Party plays the key role in governing the Soviet Union. It was the Central Committee that backed Khrushchev when he retained power in spite of the adverse vote of the Politburo in 1957. It was also the Central Committee that dismissed Khrushchev in 1964. Most of the proceedings of the Central Committee are secret. We know, however, from the published minutes of the meetings (Plenums) that they are often devoted to a special topic in foreign or domestic policy which is considered as particularly important by the Politburo. The result may be a resolution directed to certain government organs or to the Academy, as illustrated by the examples below. The March 1962 Plenum directed the Ministry of Agriculture, the Academy of Agriculture and related research institutes to improve selective breeding, animal husbandry, and mineral fertilizers. A special "Scientific Council for Chemical Processes in Agriculture" was organized in the USSR Academy of Sciences. This Council formulated a "Comprehensive Plan of Research Projects for the Introduction of Chemical Processes in Agriculture" and several three-year plans for research on mineral fertilizers and chemical products for plant preservation.

The Plenum of November 1962 was followed by a decree of the Central Committee and the Council of Ministers; this reorganized the Academy and redirected research goals to develop the social sciences and the physical sciences in order to boost technological and industrial progress, to identify new uses for existing technology, and to find new applications for the national economy.

The 25 January 1963 Plenum passed a resolution on biological research for medicine, food, light industries and agriculture, giving coordinating authority for biological research to the USSR Academy of Sciences, the Academy of Agricultural Sciences, the Academy of

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Medical Sciences, the Ministry of Agriculture, and the Ministry of Health. It is interesting to note that the Ministry of Higher and Specialized Secondary Education was requested to revise its teaching programmes for genetics, physiology, biochemistry and bio-physics. This resolution was discussed at a joint session of the Presidium and the Division of Biological Sciences of the Academy of Sciences on 1 February 1963; this resulted in an immediate increase in monies available to the Section of Chemical and Biological Sciences, both from special funds assigned to the new plan and from the redirection of funds of some institutes. The Soviet press made the most of this programme by emphasizing the responsibility of the Academy in overcoming the lag of Soviet experimental biology in genetics, physiology, biochemistry, microbiology, and radiology, and pointing to the importance of advanced work in these fields. This recurrent interest in biology and chemistry is further shown by the establishment in 1965 in the Division of General Biology of a Council for Complex Biogeocoenotic Study of Animal Nature and the Scientific Base of its Rational Utilization and Conservation. Additionally, the section for Chemical and Biological Sciences was ordered to prepare suggestions for precision instruments in biology.

The December 1963 Plenum was devoted to the development of chemical industry for agricultural and other sectors of the economy, and it directed the Presidium of the Academy to sponsor chemical research in that direction.

In 1964 the Central Committee was concerned with the introduction of computer techniques in economic analysis. It requested the USSR and the Republic Academies of Sciences to develop new mathematical methods for computer calculation and information retrieval systems, and to formulate mathematical techniques for optimum planning and administration of the national economy.

Council of Ministers

The highest legislative body in the Soviet Government is the Supreme Soviet. However its membership is only formally elective, and its powers are limited to hearing periodically the reports of the various ministers; electing the ministers, the Presidium, and the Prime Minister on a slate presented to it; and approving the Economic Plan and the Budget. In August 1966, Permanent Commissions were attached to the Supreme Soviet, covering the plan and budget, industry, transportation, and communications, agriculture and education, science, and culture. The latter undoubtedly examines the State Plan for Science and Technology. The President of the Permanent Commission on Education, Science and Culture is Sergei P. Trapeznikov, who at the same time is the head of the Department of the Central Committee for Science and Educational Institutions.

Since the Council of Ministers is a large body composed of ministers,

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chairmen of important state committees and institutions such as the State Bank and the Central Statistical office, and Presidents of the Councils of Ministers of the various Republics, the real power is concentrated in its Presidium composed of the Chairman—the Prime Minister—and 11 Vice-Chairmen. The Prime Minister is A. N. Kosygin. Included among the Deputy Prime Ministers are V. A. Kirillin (State Committee for Science and Technology), L. V. Smirnov (armaments), N. K. Baybakov (State Planning Committee or Gosplan), V. E. Dymshits (materials and equipment). Their science and technology background makes them very knowledgeable on formulating science policy at the governmental level. Furthermore, there is in the Soviet Union an interlocking of positions (both present and past) by people like V. A. Kirillin, who was at one time the head of the Department of Science and Educational Facilities in the Central Committee, and a plant engineer interested in electro-hydrodynamics, and is simultaneously an Academician, a Vice-President of the USSR Academy of Sciences, Chairman of the State Committee on Science and Technology, and Deputy Prime Minister.

The following full members of the Central Committee have scientific or technical backgrounds: A. P. Aleksandrov (1903–), Academician, President of the USSR Academy of Sciences and former Director of the Kurchatov Institute of Atomic Energy; M. V. Keldysh (1911–78), former President of the USSR Academy of Sciences and mathematician involved in space work; V. A. Kirillin (1913–), Deputy Prime Minister and expert in thermodynamics and power engineering; I. T. Novikov (1906–), Chairman of State Construction (*Gosstroi*) and Deputy Prime Minister; V. N. Novikov (1907–), Deputy Prime Minister and former President of Gosplan; B. E. Paton (1918–), Academician, welding expert and President of the Ukrainian Academy of Sciences; E. P. Slavski (1898–), since 1965 Minister of medium machine construction (military atomic energy); D. F. Ustinov (1908–), Minister of Defence; M. A. Prokofiev (1910–), chemist and Minister of Education; V. P. Elyutin (1907–), metallurgist, Doctor of Technical Sciences, Minister of Higher and Specialized Education; V. I. Utkin (1937–), automation engineer. The following is a candidate for membership in the Central Committee: G. I. Marchuk (1925–), computer specialist, mathematician and new President of the Siberian Division of the USSR Academy of Sciences.

Government Activities in Science

Various ministries deal with technology and supervising scientific establishments whose administrative structure is very complex. The major ministries are those of Defence, Agriculture, Geology, Petroleum, Means of Communication, Telegraph and Telephone, Health, the Industrial Ministries and that of Higher and Secondary Education. During the last two decades there have been a number of

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changes in the organization of the ministries. Thus the industrial ministries were abolished in 1957 and then re-established in 1965. During this period the major research institutes came under Gosplan or the various state committees, whereas the smaller ones came under the then *Sovnarkhozy* (regional economic councils). The reform of September 1965 transformed the state committees into ministries with direct control over research institutes and enterprises. The *Sovnarkhozy* were abolished. The traditional organizational scheme of research and development is a network of specialist establishments which are separate both organizationally and geographically from the industrial enterprises. Each Soviet ministry is divided into a number of chief administrations (*Glavki*). The Technical Administration guides, plans and supervises the work of the research institutes, and acts as a clearing house for new technology plans. It has an inventions and rationalization bureau and a patents bureau. The Production Administrations develop plans and proposals for the introduction of new technology, which is submitted to the Technical Administration.

The ministry also had a " Scientific and Technical Council " headed by the minister or his first deputy and composed of scientists, leading industrial workers, and representatives from the economic sector, the Party, Soviet, trade unions and the Komsomol. The Council considers the main directions for technical development such as automation, mechanization, introduction of new technology, and adaptation of the latest achievements of Soviet and foreign science and technology. It is particularly concerned with formulating a unified technical policy for the industry. The Council can set up special sections for major problems of an industry or temporary commissions on particular problems.

Each ministry has separate research and development organizations covering research, design, and capital construction. Applied research is carried out in " branch " research institutes (*Nauchno-Issledovalel'ski Institut* or NII). The major research institutes are usually called All-Union, Central, or State Research Institutes and are of three types: product design (*Proektno-Konstruktorski*), process design (*Proektno-tekhnologicheski*), and plan-design (*Proektny*). It should be noted that R & D at the factory level is very weak, with factories lacking laboratories, design facilities and experimental shops for testing prototypes of new products and processes. Soviet research institutes are divided into three categories according to their importance, and the salary scales are determined by these categories, with differentiation within each category by age, experience and qualifications. This classification was formalized in 1962 by the State Committee for Labour and Wages of the USSR Council of Ministers. Only a few of the " branch " research institutes belong to the first category, to which all the institutes of the USSR Academy of Sciences belong. Most institutes of the ministries belong to the second and third category where the salaries are lower. Many institutes and most ministry enterprises are in an

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unclassified category. The salary of a head of a factory laboratory cannot be more than 50 per cent of that of the head of an equivalent laboratory in a research institute. As a result qualified personnel tend to drift from factory to research institutes, where there is higher status, longer vacations and more interesting work. In the five-year period of 1960–65, the proportion of personnel with higher education in factory laboratories decreased from 15·8 to 14·6 per cent. A factory laboratory has the lowest priority for equipment, supplies and space. While scientific contributions from factory laboratories are negligible, the percentage of patent certificates issued to factory laboratories is 13·6 per cent greater than for any other organization except branch research organizations (46·8 per cent). The Academy of Sciences has only 9·8 per cent.

The Design Bureau (*Konstruktorskoe Buro*) is the organization responsible for designing new products. Its work is formally completed by the preparation of the working drawings which will be used for the manufacture of the prototype. While most important design bureaus operate as separate units and have their own independent budgets, others are constituent parts of research institutes or factories. The former may have their own experimental and testing facilities and may be responsible for the manufacture and testing of prototypes. The design of new production processes in existing factories is the responsibility of project-technological institutes such as the All-Union Project Technological Institute of Power Engineering.

While the amount of R & D work in those organizations is small, it must be remembered that a major part of technological innovation is associated with the construction of new factories or in the reconstruction of existing ones. Capital project organizations (*Proektnye i proektnoizyskatel'skie organizatsii obsluzhevauschie stroitel'stva*) design new plants and prepare construction plans. These are either branch project organizations in general charge of whole projects (their names often begin with the prefix GIPRO) or specialized project organizations coming under the State Construction Committee (*Gosstroi*) which plan for electrical equipment and special building in a particular industry.

Three bodies exercise overall coordination of research and development—the State Committee for Science and Technology, the State Planning Commission (Gosplan) and the USSR Academy of Sciences.

State Committee for Science and Technology

The State Committee for Science and Technology has by law the responsibility for the overall coordination of research and development except in the military area. However, in practice it shares its powers with Gosplan and the USSR Academy of Sciences. It was established in September 1965 as successor to the earlier State Committee for the Coordination of Scientific Research (1961–65, headed by M. V.

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Krunichev and K. N. Rudnev), the State Scientific-Technical Committee (1952–61, headed by Y. E. Maksaryev and K. D. Petukhov), the State Committee for New Technology (1955– V. A. Malyshev), the State Committee for the Introduction of Advanced Technology in the National Economy (1947–51, V. A. Malyshev), the Technology Department of Gosplan, the Committee on Inventions and Discoveries, the Committee on Standards and the Council on Mechanization of Labour Intensive and Heavy Work (–1947). Most of the chairmen of the above Committees were top government administrators in armaments and atomic energy. The decree of 1 October 1966 states that the task of the State Committee for Science and Technology is to " ensure the cohesion of state policy in the field of scientific and technical progress." It is required to determine the basic tendencies in the development of science. For this purpose it organizes the dissemination of scientific information. It has the general responsibility to increase the efficiency of scientific research and to introduce new technology in order to obtain maximum economic results with minimum expenditure. It has at its disposal for unscheduled research work a reserve fund from the state budget and a reserve of scientists. These reserves can be increased by cancelling grants for current, non-productive research. It can participate with Gosplan and the State Committee for Material Supplies in the distribution of special equipment for important research projects. Together with the Academy of Sciences, ministries, and other organizations, the State Committee scrutinizes the principal projects completed by the Academy institutes and institutions of higher learning in order to organize successive stages of research development and the introduction of the results into the economy.

The organizational structure of the State Committee for Science and Technology consists of the General Assembly of the Committee, the *Kollegia* of the Committee, the Science Councils, the Administrative Staffs, and Institutions attached to the Committee.

The General Assembly of the Committee consists of the Chairman (V. A. Kirillin), a number of Vice-Chairmen including Dzherman M. Gvishiani, son-in-law of Premier Kosygin), the President of the USSR Academy of Sciences, the Vice-President of Gosplan, the Minister of Higher and Specialized Secondary Education, the President of the State Committee for Inventions and Discoveries, a number of leading personalities from industry and science, and probably heads of departments of the State Committee for Science and Technology. The General Assembly of the Committee has policy-making functions.

The *Kollegia* of the Committee is nominated by the Council of Ministers. Its functions are not known.

The complex Science Councils supervise the work on the major problems included in the plan of the State Committee. It is the task of the Council to overcome barriers between the several R & D establishments working on the same problem but under different authorities.

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They are composed of leading scientists, industrialists, and specialists from research institutes and academic institutions. The councils have the responsibility for analysing the state of research in their field; they organize and coordinate research, hold conferences periodically to exchange information, and at times publish the results of such conferences. While the Councils have no budget and very small staffs, their recommendations and assessment of the various projects carry great weight in the planning and control operations. In 1961 there were 24 Science Councils. Their number in 1965 was 33. A list of some of the Science Councils attached to the State Committee for Science and Technology are:

Automation and Mechanization of Industrial Processes
Electronic Technology
Study of Complex Utilization and Reworking of National Resources
Energy and Electrification (G. V. Aleksenko, Chairman)
Study of the Oceans and Seas and the Utilization of their Resources (E. K. Fedorov, Chairman)
Catalysis and its Industrial Utilization (G. K. Boreskov, Chairman)
Chemistry of the Natural and Biologically Important Compounds
Chemical Processes in Agriculture (S. I. Volfkovich, Chairman)
New Materials Based on Glass
New Welding Processes and Welding Construction (B. E. Paton, Chairman)
Polymeric Materials in the National Economy (V. A. Kargin, a recently deceased Chairman)
Use of Rare Metals in the National Economy (A. P. Vinogradov, Chairman)
Development and Introduction of Mathematical Methods, Computational Technology and Automatic Control and Information Processing in the National Economy (V. M. Glushkov, Chairman)
Rare Elements
Synthetic Materials Based on Polymers
Development of New Metallurgical Processes

The State Committee for Science and Technology has its headquarters at the head of Gorky Street, diagonally across from the Council of Ministers. It is divided into a number of departments: Foreign Relations (Dzherman M. Gvishiani, Vice-Chairman of the Committee in Charge), Scientific-Technical Information and Propaganda, Scientific-Organizational Forest and Construction Industry, Chemistry and others. Little is known about the personnel and functions of these departments.

A number of institutions are attached to the Committee. A consortium of Publishing Houses for Scientific Research Material, both Soviet and foreign, was once associated with a predecessor organization. This type of activity has been widespread in the Soviet Union and highly organized to keep the Soviet scientists abreast of what is

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going on in the West. Special collections of important articles on a specific subject of scientific or technical interest are translated and published.

The Exhibition of the Achievements of the National Economy of the USSR is under the supervision of the State Committee. This massive exhibit, similar to a World's Fair exhibition, is located on the outskirts of Moscow and is an example of popular education in science and technology coupled with amusement and relaxation.

The All-Union Institute of Scientific and Technical Information (VINITI) is, as its name indicates, the main centre for the collection and coordination of scientific and technical information. In addition to this central group, in 1962 there were 84 institutes and bureaus working at the All-Union level, collecting and transmitting scientific information, with their work being coordinated by the Department of Scientific Information and Propaganda of the State Committee.

State Planning Commission

The State Planning Commission (Gosplan), along with the State Committee for Science and Technology and the Academy of Sciences, plays an important role in the formulation of Soviet science policy and the introduction of new technology into the national economy. Like the Academy of Sciences, Gosplan supervises its own scientific establishments. Since research and development are an integral part of the national economy and must be considered in the National Economic Plan, Gosplan, being in charge of coordinating the plans of all Soviet agencies, must also be the main coordinator of research and development. Prior to 1948, R & D was included in the financial investment, manpower and supply plans of the organizations supervising research. Since then, a number of agencies have been created to act as separate coordinating bodies for R & D, ultimately resulting in the State Committee for Science and Technology. After a variety of changes in authority for planning, it seems that the general overall planning of science and technology has returned to Gosplan with the creation in 1966 of a "Department for Comprehensive Planning of the Introduction of New Technology into National Economy."

The full name of Gosplan is the State Planning Committee of the Council of Ministers of the USSR. It is an All-Union organization responsible for planned development of the USSR economy and for control of the fulfilment of the national economy plans. It was established by a decree of the Council of People's Commissars on 22 Febuary 1921. Since that time the objectives and functions, structure, and methodology have changed considerably. The main objectives of Gosplan under contemporary political and economic conditions, as stated by the September 1965 Plenum of the Central Committee, are the development of plans in accordance with the programme of the Communist Party, the directives of the Party Con-

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gresses, the instructions of the Central Committee, and the decisions of the Council of Ministers. In addition to five-yearly plans, Gosplan formulates both long-range and yearly plans, intended to assure a proportional development of the national economy, continued growth, and increased efficiency of the national industry in order to increase the standard of living and strengthen national defence. Gosplan attempts to base plans on contemporary accomplishments and progress in science and technology on the results of scientific investigations of the economic and social problems of communism and a comprehensive study of social demands. The plans must reflect a proper relationship between regional and territorial planning and central planning, preserving at the same time the economic independence of enterprises and organizations. The planning is carried out with the cooperation of ministries, agencies, Gosplans of subordinate republics and scientific organizations. Gosplan also formulates measures that will ensure further technical progress; rapid utilization in the national economy of recent accomplishments of science and technology; increase in the manufacture of new products with technically advanced qualitative characteristics; comprehensive mechanization and automation of production; increase in effectiveness of capital investment; and acceleration of the productiveness of basic capital and new enterprises. Gosplan also develops growth indices for labour productivity, the utilization of labour resources, the supply of trained manpower, increase in profitability of production, and better utilization of financial resources.

Gosplan also prepares proposals for the coordination of development plans of the Soviet economy with those of other communist bloc countries. Gosplan uses the so-called "balanced method of planning." It works up material and labour and cost balances, as well as an overall balance for the USSR and for the individual republics. For maximal accounting of the accomplishments of scientific-technical progress by utilization of reserves of enterprises it uses progressive technical-economic norms, applying to expenditures of labour and material resources in industry and construction specific capital investment and technical-economic indices for the utilization of productive capacity. Gosplan also uses a variety of forecasting techniques. This facilitates the establishment of appropriate cost proportions in the means of production and consumer goods, industry and agriculture, consumer production and construction, production and transportation, retail trade, service to the population and financial income of the population. Calculations and bases for the plans are carried out using economic-mathematical methods and electronic computers. Gosplan exercises control over the execution of economic plans by ministries, agencies, associate republics, enterprises and organizations; it produces support for further development of industry and increases in economic indices; and it reports periodically to the government on the course of the fulfilment of the plans. Gosplan can issue decrees which are

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binding on all ministries, agencies and other organizations. It has the authority to call in for the development of plans and specific problems of the national economy the USSR Academy of Sciences, the Academies of Sciences of the subordinate republics, the research and design institutes, construction organizations, and individual scientists, specialists, and leading production experts.

Gosplan consists of the chairman of the committee appointed by the Supreme Soviet, deputy chairmen, and members appointed by the Council of Ministers. Operational direction of Gosplan is vested in a collegium consisting of the chairman, the deputy chairmen and tha important managers in the apparatus of Gosplan. The apparatus consists of branch and coordinating sections. Branch sections are organized for branch industries, for agriculture, cultural activities, science and education, health, housing and communal economy, and daily servicing of the population. These sections operate with due consideration for proposals submitted by ministries, agencies and republics, future projects and present plans for the development of their immediate branch of industry and of other branches of the national economy. At the same time they ensure, along with the auditing sections of Gosplan, coordination of the needs of the national economy with the available resources. The branch sections develop measures for utilizing available reserves for improving production. The coordinating centres (involving the coordinating sector of the national economy plan and sections for theoretical planning, distribution of productive forces, capital investments, material balances and distribution plans, labour finances and cost of production) develop the projects of national economy for the whole country in branch and territorial sections, guaranteeing the necessary coordination, balancing, and proportional development of the branches of the national economy. They prepare systems of indices, forms, and methodological instructions for preparation of the national plans, analyze the fulfilment of the plans, prepare reports for Gosplan and the Council of Ministers, and coordinate the work of Gosplan branch sections.

Gosplan has a number of commissions and organizations. The State Expert Commission consists of prominent scientists and specialists, and it gives expert advice on important problems of the national economy, general schemes for the development of branches of the national economy and the distribution of enterprises, and specialization and comprehensive development of the economic regions and projects of massive construction. An Interagency Commission on Questions of Economic Reform (1965) has the responsibility for the methodological direction in the realization of economic reforms in the national economy, for studying and generalizing experiments involving the application of new systems of management in branch economy, and for the development of further growth and perfection of the planning system,

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and economic stimulation. It also prepares proposals for the improvement in the organization and management of production. Gosplan has a Main Computer Centre which, using electronic computers, calculates the plan indices on orders from branches of Gosplan. Gosplan has a Scientific Research Economic Institute, a Council for Study of Productive Forces, an Institute of Complex Transportation Problems, and a Scientific Research Institute for Planning and Norms. Gosplan publishes handbooks such as *Plannovoe Khozyaistvo* (Planned Economy).

The incorporation of targets for research and development into a national plan poses great difficulties not only for the Soviet Union, but also for the US and Western European countries. The problem, however, is a more difficult one for the USSR because central planning is so important to them. The research and development process is divided into the following stages: exploratory work, research (about five years), experimental and pilot plant work, preparation of production for inclusion of new projects (seven more years), and introduction of results of research into the national economy (indeterminate time). Thus the whole operation takes over 10 years and is difficult to plan on a large scale. The R & D targets are divided for purposes of national planning into fundamental problems of chemistry, physics, mathematics, biology, geology, social sciences and humanities, branch problems in improvement of production, territorial problems in the development of productive forces, and inter-regional and inter-branch problems. In addition to exploratory work in specific areas, there is work on diffuse problems such as "New Processes in Metallurgy" and "Energy and Electrification." There are fundamental difficulties in incorporating research and development into the national plan. In the first place, R & D plans cannot be divided conveniently into quarterly, annual, and five-year intervals. Secondly, it is difficult to establish indices of performance and plan fulfilment. While the input can be evaluated in terms of expenditures for wages and supplies, the output cannot be similarly evaluated. It is also difficult to integrate the accomplishments of R & D effort with production goals. For even if the product is introduced into the national economy as new technology, such as mechanization and automation of current production or production of a new product, it is difficult in the Soviet system to evaluate the economic gains and losses. The cost of each element in the productive process cannot be isolated and its cost evaluated. At the same time, the price of a new product or an old product produced by a new method can be determined only with difficulty in the Soviet system because it does not have a practical solution to the pricing problem.

Gosplan has annual, five-year and long-range plans. The plans for science and technology were first explicity included in 1949, and since then have appeared or been embedded in the annual plan. The 1965 Research and Development Plan was the most comprehensive in Soviet planning. However, the plan for 1967 reduced the numbers of chapters,

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problems, subjects, and works from previous plans and included only " the most important scientific and technical problems of great interest to the national economy." The research and development targets in the National Economic Plan for 1967 included the following:

1. The Sectors on Scientific Research Works and the introduction of results of science and technology in the USSR economy had the following targets in the various sectors:
   (a) Scientific research and exploratory work
   (b) Design and production and exploratory work
   (c) Directives for initial serial production
   (d) New methods in mechanization and automation
   (e) List of obsolete items to be withdrawn from production
   (f) Assimilation by consumers of new items and processes
   (g) Promotion of specialization and cooperation in production.
2. The Sector on Capital Construction also had science and technology targets.
3. Similarly, the Sector on Material and Technical Supplies had science and technology targets.
4. The Sector on Employment and Cadres had targets covering employment in the scientific establishment.
5. The Sector on Cost of Production and Distribution addressed itself to the cost of production of new technology.
6. The Sector on Public Education, Culture, and Health devoted attention to the education of scientists for all important branches of science and technology.
7. The Sectors on National Income, Balance of Population, Cash Incomes and Expenditure, and Balance of Financial Resources and Their Utilization addressed themselves to the monetary incomes of scientists and auxiliary scientific personnel.

The State Budget has the following sections devoted to science and technology:

1. National Economy—subsidies for investments allowing financing and contracting of research and the introduction of new technology.
2. Social and cultural measures—direct financing of " Science " as a subdivision of the section on " Education."
3. Ministry of Defence—subsidies for financing research and introduction of new technology.

The five-year plans were initiated in 1928, and the Soviet Union is currently in the tenth five-year plan, 1976–80. Information concerning research and development included in these plans is very limited. The targets for R & D were grouped in a special section in the 1966–70 plan, and the subdivision is almost identical to the subdivisions in the 1967 plan, namely mechanization and automation of productive processes, development and production of prototypes, scientific research and development work, scientific research and development work in natural sciences and social studies, production of new industrial products, financing of scientific research, numbers of scientific workers,

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and formation of scientific personnel. The 1966–70 plan had 1,400 targets for research and development associated with "solution" of the 240 most important scientific and technical problems. Some of these problems were to be "solved" in cooperation with countries of the Council for Mutual Economic Cooperation. The various ministries formulate "Coordination Plans," providing links between the five-year plan and the individual annual plans by specifying whole groups of activities, appropriate time limits, organizations executing the projects, and successive stages of planned work. It is possible that the function of the annual plans is to "up-date" the annual targets included in the five-year plans and thus have "continuous planning."

The research and development planning process for an annual plan consists of the following stages: transmission of directives to lower organs (February-June); presentation of draft plans to higher authorities (June-September); approval of plans and their transmission to scientific establishments and lower organs (November-end of January of planned year); and plan adjustments (during planned year) by authorities who approved the plans. This is of course the ideal schematic schedule. In practice, both lower and higher organs are engaged simultaneously in the planning process. There has been some difficulty in that the State Plan for Introduction of New Technology was formulated after the routine plans for production, construction and material supplies so that it lacked financial means and material resources. Financial allocations were replaced by credits from the State Bank. However, material resources could not be obtained easily. The requirements for materials, equipment and instruments are not automatically met through allocation of funds or through inclusion in the National Economic Plans. These requirements must be included in the Plan for Material Supplies, which is a special sector of the Plan. Separate allocations are made for organizations like the Academy of Sciences and for R & D organizations not engaged in production. Deliveries are carried out by the State Committee for Materials and Technical Supplies.

The materials supply system, however, is highly inefficient, as was evident from the creation of a separate Ministry for Production of Instruments, Means of Automation, and Control Systems with a top Soviet executive, K. N. Rudnev, in charge. It has a Chief Administration for Scientific Instruments. But despite great efforts to produce scientific instruments in the Soviet Union, its instruments in general are of low quality. As a result, many of the standard instruments are obtained from East Germany, Japan, Czechoslovakia and Western Europe, and there has been a continuing Soviet interest in obtaining instruments from the US.

The USSR Academy of Sciences

The Academy of Sciences of the USSR is the highest scientific

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establishment in the country. It has full members (academicians), corresponding members, and foreign members who are prominent scientists both in the USSR and abroad. The basic objectives of the Academy include fundamental investigations in physical, natural, and social sciences; scientific investigations associated with the development of production and discovery of new possibilities of technical progress; and cooperation for the most complete utilization of scientific accomplishments in "building Communism" in the USSR. The Academy also carries out graduate education (*aspirantura*) in a limited way.

The Academy is directly under the control of the Council of Ministers of the USSR. It has general scientific control over investigations of the most important problems in sciences and social studies in the USSR, including those carried out by the Academies of Sciences of the subordinate republics and other scientific establishments and institutions of higher learning.

The General Assembly of academicians and corresponding members is the highest organ of the Academy. It meets at least twice a year to discuss the development of science in the USSR, to decide on basic organizational problems, to elect academicians and corresponding members, and every four years to elect a President of the Presidium, Vice-Presidents and Academician Secretary. Unlike other organizations, the elections of members to the Academy are secret.

The Presidium of the Academy is the top executive body of the Academy. It has control over four Sections (*sektskii*) of the Academy, and the following other groups and institutions: the Republic Academies through its Council for Coordination of Scientific Activities of the Republic Academies of Sciences, the Siberian Branch of the Academy, branches and scientific centres of the Academy, Scientific Councils, Committees, the Division for Applied Problems, the Publishing Council, the Publishing House *Nauka*, related libraries, and the permanent academy exhibit.

The Presidium of the Academy is located in an imposing old residence on Leninsky Prospect. The Apparatus of the Presidium consists of the following departments: The Chancellery, Adminstrative (Housing and Communal Affairs), Personnel, Planning and Financial, Scientific Organization, Foreign, and Scientific Relations with the Socialist Countries.

The President of the USSR Academy of Sciences is a dominant figure in Soviet society. He is not only a leading scientist and administrator but an active party member. The current President, elected on 25 November 1974 is Anatoli Petrovich Aleksandrov (1903–), a leading figure in atomic physics. Born in the Ukraine, he graduated from the University of Kiev in 1930 and worked in the Physico-Technical Institute of the USSR Academy in Leningrad. During the period of 1946–55 he was director of the Institute of Physical Problems of the Academy. Since 1960 he has been the

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Director of the Kurchatov Institute of Atomic Energy. He was elected corresponding member of the Academy in 1943 and Academician in 1953. Since 1960 he has been a member of the Presidium of the Academy, where he has been active in coordinating the activities of the USSR Academy and republic Academies in the field of atomic energy. The scientific interests of Aleksandrov are electrical properties of dielectrics, solid state physics, and theory of electric and mechanical relaxation of polymers. During World War II Aleksandrov directed the work on protection of ships from mines. At the end of World War II, Aleksandrov transferred his activities to atomic energy and has been director of important aspects of this development in the Soviet Union, particularly reactor construction. He also organized the section on the physics of solid state, which has produced important technical results in super-conductors. Together with I. V. Kurchatov, he organized in this institute a biological section which has become one of the centres of molecular biology in the Soviet Union. He became a member of the Communist Party in 1962 and was elected member of the Central Committee in 1966. He has been a deputy of the Supreme Soviet of the fifth and sixth Sessions. He has been awarded many honours: three times Hero of the Socialist Labour, Laureate of the Lenin Prize and the State Prize, and seven Lenin Medals.

The previous presidents of the USSR Academy of Scientists were A. P. Karpinski (1917–36), a geologist; V. L. Komarov (1936–45), a botanist; V. I. Vavilov (1945–51), a physicist; A. N. Nesmeianov (1951–61), an organic chemist, and M. V. Keldysh (1961–75), a mathematician. The election of the president and members of the Presidium is for four years; a statute of the Academy states that they can be re-elected only once. This limit, however, is not observed.

Details of the members of the Presidium elected at the November 1974 meeting now follow.

The vice-presidents are V. A. Kotel'nikov, born 1908, specialist in radio-engineering and electronics, Party member since 1948; A. A. Logunov, born 1926, quantum field theory and physics of elementary particles, Party member since 1960; Y. A. Ovchinnikov, born 1934, bio-organic chemistry and molecular biology, Party member since 1962; A. V. Sidorenko, born 1917, geology; P. N. Fedoseev, born 1908, Marxist philosophy, and C. L. Marchuk, born 1925, applied mathematics, President of the Siberian Division of the Academy, Party member since 1947.

The post of the General Scientific Secretary of the Presidium of the Academy is very powerful. It has been officially vacant for a number of years, though the Acting General Scientific Secretary has been G. K. Scryabin, born 1917, industrial microbiologist and biochemist. He graduated in 1942 from the Kazan Veterinary Institute and served in the Soviet Army from 1943 to 1946. From 1946 to 1949 he did graduate work in the Moscow Veterinary Institute. Since 1949 he has

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worked at the Academy's Institute of Microbiology and Institute of Biochemistry and Physiology of Micro-organisms. He has been the director of the latter institute since 1962. He received his doctorate in 1967. Since 1967 he has been the director of the Scientific Centre of Biological Investigations at Pushchino. He has been a leader in the Soviet Union in the production of antibiotics, microbiological transformations of chemicals, and the production of proteins from petroleum. He is a son of a famous Soviet helminthologist, Konstantin Scryabin. He has been a member of the Communist Party since 1947 and a corresponding member of the Academy since 1968. Scryabin is only Acting Chief Scientific Secretary and not the permanent secretary because the latter post is filled by an academician and Scryabin has not been elected to this rank. But he is a member of the Presidium. The other members of the Presidium are the academician-secretaries of the different sections:

A. A. Baev, born 1904, biochemist.
N. N. Bogolyubov, born 1900, mathematician and theoretical physicist.
L. M. Brekhovskii, born 1917, physicist. Director of the Division of Oceanography, Atmospheric Physics and Geography.
M. S. Gilyarov, born 1912, zoologist.
A. G. Egorov, born 1920, philosopher. Editor of the main Party journal, *Kommunist*. Candidate Member of the Central Committee.
N. M. Zhavoronkov, born 1907, inorganic chemist and chemical engineer.
E. M. Zhukov, born 1907, historian.
P. G. Kostyuk, born 1924, neurophysiologist.
M. A. Markov, born 1908, nuclear physicist.
B. N. Petrov, born 1913, specialist in automatic control.
A. M. Prokhorov, born 1916, physicist, Nobel Laureate.
B. S. Sokolov, born 1914, paleontologist.
M. A. Styrikovich, born 1902, thermal engineer.
N. P. Fedorenko, born 1912, economist.
M. B. Khrapchenko, born 1904, specialist in literature.
N. M. Emanuel, born 1915, physical chemist.
S. V. Vonsovski, born 1910, physicist. President of the Presidium of the Ural Scientific Centre.
A. A. Trofimuk, born 1911, first vice-president of the Siberian Division of the Academy.
A. P. Kapitza, born 1931, geographer, corresponding member, President of the Presidium of the Far Eastern Science Centre of the Academy.

In addition to the above ex-officio members, the following academicians were elected members of the Presidium:

V. A. Ambartzumian, born 1908, astrophysicist. Party member 1940.

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N. G. Basov, born 1922, physicist. Nobel Prize 1964. Party member 1951.

I. N. Vekua, born 1907, mathematician and expert in mechanics. Party member 1943.

N. N. Inozemtsev, born 1921, historian and economist. Party member 1943. Central Committee member, editor of *Pravda.*

P. L. Kapitsa, born 1894, physicist.

M. V. Keldysh (1911–78), applied mathematician and expert in hydrodynamics. Former president of the Academy. Party member 1949. Central Committee member.

M. A. Lavrentiev, born 1900, mathematician, former president of the Siberian Division of the Academy. Party member 1952; Central Committee (candidate member).

N. V. Mel'nikov, born 1909, mining engineer. Party member 1944.

A. N. Nesmeianov, born 1899, organic chemist. Formerly President of the Academy. Party member 1944.

B. E. Paton, born 1918, expert in metallurgy and welding. President of the Ukrainian Academy of Sciences. Party member 1952. Central Committee member 1961. Vice-President Supreme Soviet.

N. A. Pilyugin, born 1908, expert in automation and space rockets. Party member 1940.

P. N. Pospelov, born 1898, historian and Party leader. Party member since 1916. Member of Central Committee and Candidate Member of the Politburo.

A. S. Sadykov, born 1913, organic chemist. Party member since 1946.

N. N. Semenov, born 1896, physical chemist. Nobel Laureate. Party member 1947.

V. M. Tuchkevich, born 1904, solid state physicist. Party member 1952.

R. V. Khokhlov (1926–77), physicist. Expert in non-linear optics. Rector of Moscow University. Member of the Party 1952.

The Academy is divided into four sections and each of these into individual departments. These are listed below:

1. Physics—Technical and Mathematical Sciences. A. A. Logunov.
   (a) Mathematics
   (b) General Physics and Astronomy
   (c) Nuclear Physics
   (d) Physico-Technical Problems of Energy
   (e) Mechanics and Control Processes.

2. Chemico-Technological and Biological Sciences. Yu. A. Ovchinnikov.
   (a) General and Technical Chemistry
   (b) Physico-Chemistry and Technology of Inorganic Materials.
   (c) Biochemistry, Biophysics and Chemistry of Physiologically Active Compounds.
   (d) Physiology
   (e) General Biology.

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3. Earth Sciences—A. P. Vinogradov (died last year).
   (a) Geology, Geophysics and Geochemistry
   (b) Oceanography, Geography and Atmospheric Physics.
4. Social Studies—P. N. Feodoseyev.
   (a) History
   (b) Philosophy and Law
   (c) Economics
   (d) Literature and Language.

The administrative structure of each of the four sections consists of a Vice-President of the Academy who acts as Chairman, the Secretary-Academician of the sector, and the Secretary-Academicians of departments in the sections.

Each department is headed by an academic secretary, who is elected by the members of the department and is also a member of the Presidium. The Presidium approves and controls all research plans and the international contacts of the Academy. The establishment of scientific institutes and councils and their personnel must have the approval of the Presidium. The departments in turn are controlled by the academic secretary, his deputy and a limited bureau. Most of the administrative work is carried out by the apparatus of the Presidium. Control over research institutes has varied over the last few decades. But it seems that since the Decree of 1963, the administrative and scientific supervision of the research establishments has been under the direct control of the sections.

The scientific establishments of the Academy are research institutes, laboratories, experimental stations, observatories, libraries and museums, with the research institutes being the most important scientific organizations. The scientific work of the institutes is determined by the Presidium of the Academy on the basis of proposals made by the bureau of the appropriate department and the approval of the pertinent section. The head of an Academy institute is a director, elected for a four-year term by the general assembly of the department with the subsequent approval of the General Assembly of the Academy and confirmation by the Presidium. The institute director determines the use of financial resources allocated to his institute. He has some freedom to modify construction projects not foreseen in the plan and to by-pass material supplies authorities in the purchase of materials. Assistant directors and chief academic secretaries of the institutes are appointed by the Presidium on nomination by the directors of the institutes.

The scientific council of an institute is appointed by the director and consists of leading scientists of the institute, representatives of the trade union organizations and of the Party. Ordinarily its function is advisory, but it also has the right to award the degrees of Candidate or Doctor of Sciences if the institute has that power.

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The institute is usually divided into research departments (*nauchnye otdely*) and these, in turn, into laboratories and research sections.

The Presidium, sections of the Presidium and the departments of the Academy have over 200 councils advising the Academy on important problems in the sciences and social studies. These science councils vary in importance and activity—the 27 science councils for the Complex in Natural and Social Sciences have the same degree of importance as those attached to the State Committee for Science and Technology. The important councils in the last decade have been those for

Bio-Organic Chemistry
Cytology
Solid State Physics
Physico-Chemical Principles of Metallurigal Processes
Physico-Chemical Principles for Extracting New Heat-Resistant Inorganic Materials
Physico-Technical Problems of Processing Minerals (attached to the Department of Earth Sciences)
Physiology
Physiology of Humans and Animals
Photosynthesis
Genetics and Selection
Chemistry of High Energy Particles
Chemical Thermodynamics and Thermochemistry
Cybernetics
Complex Biogeocoenotic Study of Animate Nature and Scientific Basis of its Rational Use
Complex Research of Earth's Crust and Upper Mantle
Cosmic Rays
International Space Cooperation
Methods of Direct Transformation of Thermal Energy into Electric Energy
Molecular Biology
Scientific Principles of Application of Chemicals in Agriculture
Petrochemistry
Radiobiology
Radioastronomy
Seismology
Synthesis, Study and Application of Absorbents
Theory of Chemical Structure, Kinetics of Reactivity and Catalysis
Theoretical Basis of Soil Science
Fuel Elements
Control of Heredity and Viability of Plants, Animals, and Microorganisms
High Molecular Weight Compounds
High Temperature Thermal Physics
Pattern of the Individual Development of Animals and the Control of Ontogenetic Processes.

The Complex Councils influence the entire Academy system, the

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Republic Academies, Agricultural and Medical Academies, and also the Institutions of Higher Education. They are composed of prominent scientists, specialists from research establishments in industrial enterprises and institutions of higher education. The Complex Councils analyse the state of research in their fields, coordinate research, develop plans, and evaluate results. They serve to draw scientists into decision-making on important scientific and technological problems.

Siberia is a large, undeveloped territory with unusual mineral wealth, extensive forests and large potential agricultural acreage. At the request of a number of scientists, the Council of Ministers approved in May 1957 the organization of a Siberian division of the Academy of Sciences with headquarters in a new science city. The result was the establishment of a massive scientific centre at Akademgorodok, forty kilometres from Novosibirsk; now it is a city of about fifty thousand inhabitants, with some twenty institutes, a university and an industrial plant to build scientific equipment. Its first President and founder is M. A. Lavrentiev, a famous mathematician.

Most of the scientific work in the USSR has been concentrated in Moscow, Leningrad and Novosibirsk. This has been a matter of concern to administrators of Soviet science. Various organizational schemes have been initiated to locate basic research activities more uniformly over the Soviet Union. The establishment of the Siberian Division of the USSR Academy, the academies of the subordinate republics, and the filials (branches) of the USSR Academy are organizational schemes that are used for this purpose. The republic academies are those of Azerbaidzhan, Armenia, Estonia, Georgia, Kazakhstan, Kirghizia, Latvia, Lithuania, Tadzhikistan, Turkmenia, Ukraine, Uzbekistan and White Russia.

The Academy of Sciences of the USSR has a number of filials or branches in the smaller republics and selected regions of the Soviet Union. Like the republic academies of sciences, the filials must carry out theoretical investigations, both in basic science and in facilitating the development of the economy and culture of the region. There are eight filials: Ural, Kazan, Bashkir, Dagestan, Moldavia, Kala, Kareleia, and Arkhangelsk.

The problem of planning scientific research has been a difficult one for the Academy of sciences. In his report for 1975, Acting Secretary Scryabin noted:

> In 1975 and in previous years an important place has been devoted in the Academy to the question of planning of scientific investigations and forecasting science. The increasing importance of this work, particularly the long-range planning and forecasting, is associated with the constant expansion of the front and scale of scientific investigations, with the increasing complexity and interrelationship of the problems. Up to 1972, forecasts of the development of a series of important directions in science were made. In 1972–73, the Academy of Sciences together with the State Com-

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> mittee for Science and Technology carried out a large project in compiling "Coordinated Programme of Scientific-Technological Progress and its Social-economic Consequences for 1976–90.

In his address to the 25th Party Congress, Secretary General Brezhnev stated:

> Acting on direction of the Central Committee and the government, the Academic Institutes together with the ministries and agencies propose a project of coordinated programmes on scientific-technological progress and its social-economic consequences for 1976–90. The work on this programme must be continued. It embodies an organic component of the current and long-range planning. It gives directions. Without this knowledge we cannot successfully direct the economy.

Scryabin further noted:

> The Basic Directions for Development of the National Economy of the USSR for 1976–80 were formulated with due regard to "the Coordinated Programme." The Academy of Sciences has worked out 38 programmes of investigations in natural and social science for the period up to 1990. Scientists of republican and distant academies of sciences took part in formulating this programme: the "Basic Directions for the Development of Natural and Social Sciences for 1976–80," formulated by the Academy in 1973–74, has been sent to the organizations which are involved in the plan for use in formulating the plans for scientific research work.

Academician Kotel'nikov, who directed the work on the "Coordinated Programme" spoke of the importance of continuing work on the Coordinated Programme.

Academician Kirillin, Chairman of the State Committee for Science and Technology, noted the following on planning:

> The report of the General Secretary of the Central Committee, L. I. Brezhnev, the speeches at the Congress and also those at the present meeting of the Academy discussed programmes for investigation of important directions for science and technology.
>
> What do we actually plan to do to improve the planning of new science in the tenth five-year period?
>
> Up to now we have had the following practice: we approved the listing of about 200 scientific technical problems as well as basic directives for their solutions which were introduced into the National Economy Five-year Plan. The State Committee for Science and Technology approved for each problem a detailed coordinated plan.
>
> Now instead of a coordinated plan for each programme, a scientific-technical programme is formulated. This is not merely a change of name. First of all, these programmes are going to deal with complex questions which can be solved only by the combined effort of two or three or larger numbers of ministries

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and other organizations. Furthermore, the majority of these programmes must be carried out to achieve concrete practical results: either production of a machine, development and realization of a new technological process, or the formulation of new material.

Since some of these programmes are large and complicated, they cannot be completed during one five-year period. Consequently, part of the work can be transferred to the next period.

The most important condition for the actual completion of such a programme is the timely and complete support (financial and material-technological) of everything that is necessary for its realization, on the level of the National Economy plan. The USSR Gosplan has discussed this problem and has made the appropriate decision. As a result it seems that the programmes themselves (and there are more than 200 of these which are now in the final stage of formulation) are not going to be included into the National Economy Plan since this is too unwieldy. The plan will have only the directives on basic scientific-technological programmes, which envisage their financial and material-technological support. This large task, started before the Congress, is carried out together with the Academy of Sciences, ministries, agencies and other organizations.

This is the qualitative difference in planning scientific-technological progress in the 10th five-year plan in comparison with the previous one. It is important to emphasize, as I had previously stated, that these programmes are going to be carried out to achieve concrete practical results and are to have material and financial support.

As for fundamental investigations, it is not envisaged to include such programmes in the National Economy Plan. The Academy of Sciences is going to be concerned with the planning of these investigations. It is envisaged that this arrangement will be preserved in the future.

Thus it can be said that the Soviet system apparently has not solved the problem of how to plan science and technology development during the technological revolution. This has been affected by the interaction of the Party and the Academy. An interesting example of such interaction has been the appearance of Party Secretary Suslov at the Academy meetings.

The General Assembly of the Academy was convened on 9 May 1975, to consider organizational problems associated with the expiration of the mandate of the then Presidium of the Academy, and with the request of Academician Keldysh to be relieved of his duties as the President of the Academy of Sciences. On that occasion, M. A. Suslov, who is a member of the Politburo and Secretary of the Central Committee, addressed the meeting in the following terms:

During the past several months, Academician Keldysh has raised many times and forcefully the question of his relief from his duties as the President of the Academy because of his health

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> and the consequent impossibility of exercising his responsibilities in a proper way. Knowing with what sense of responsibility Comrade Keldysh considers his duties as president and the activity of the Academy, we in the Central Committee gave much time to the discussion of his request and persuaded Mstislav Vsevolodich to continue work in the post he occupies.
>
> However, recently, particularly with the approach of the termination of the tenure of the Presidium of the Academy, Mstislav Vsevolodich renewed his request to be relieved from the post he occupies and did not approve his candidacy for election to the Presidency of the Academy for a new period. Keeping in mind the insistent requests and the state of health of Comrade Keldysh, we finally were forced to accept and agree with his wishes.

After praising the work of Keldysh and discussing the plans for the celebration of the 250th Jubilee of the Academy, Suslov stated:

> The Jubilee session devoted to the 250 years of the founding of the Academy is an important event in the social life of the country. Considerable preparative work has been carried out for it by the present Presidium and therefore it is quite proper and desirable that the composition of the Presidium, which directed this work, would lead it to the end and complete the jubilee arrangements. Having complete confidence in the present composition of the Presidium, the Central Committee of the Party considers it appropriate to extend the credentials of the Presidium until the Jubilee arrangements are completed. The Central Committee assumes that you will agree with the proposal to carry out the Jubilee festival under the direction of the present composition of the Presidium and that you will make the appropriate decision. The present Presidium of the Academy will participate in the development of the national economy during the next five-year period and also for the more distant perspective. In the coming months additional effort will be asked from it. This also makes it sensible to extend the mandate of the Presidium. The Acting President of the Academy will continue to be V. A. Kotel'nikov.

After speeches by Kotel'nikov and other academicians, the Suslov proposals were accepted.

On 25–27 November 1975, the Academy of Sciences had a general meeting devoted to the election of a new president. The meeting was chaired by Acting President Kotel'nikov who, in the name of the Presidium of the Academy, nominated A. P. Aleksandrov. The first speech approving the nomination was by Suslov, who said:

> As you remember in May of the current year, the General Assembly of the Academy of Sciences extended the mandate of the present Presidium of the Academy and decided to carry out the election of the directive organs in November.
>
> Now this time has come. You are to elect the President of the Academy, the membership of a new Presidium and of the directing organs of the divisions, academician-secretaries, the bureaus of

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> the divisions which must directly control the work of scientific establishments for the solution of the most promising important problems of modern science.
>
> The Central Committee of the Party has attentively studied these questions and first of all the question of the candidacy for president.
>
> Based on the advice of scientists, and considering and carefully weighing their wishes, we came to the conclusion that the worthy candidate for the high and responsible post of the president of the Academy of Sciences is Anatoli Petrovich Aleksandrov, three times hero of Soviet Labour, Laureate of the Lenin and State Prizes and member of the Central Committee.

Suslov then praised the accomplishments of Aleksandrov. He also praised the accomplishments of the Academy since the 24th Party Congress. He then stated that the celebration of the 250th Jubilee of the Academy showed the accomplishments of Soviet science. He ended as follows: "The Party gives primary significance to fundamental scientific investigations in areas of natural and social sciences, which are the basis for the development of all science, scientific-technological progress and an understanding of the laws of development of society."

The interaction of the Party and the Academy was very visible at the Annual General Meeting of the Academy on 17–18 March 1976. The Presidium of the meeting consisted of the new President of the Academy, A. P. Aleksandrov, the Vice-Premier of the Soviet Union, Academician Kirillin, and three Party leaders, M. A. Suslov, leading member of the Politburo, Academician V. N. Ponomarev, candidate member of the Politburo, and Mikhail V. Zimyanin* (1914–), secretary of the Central Committee.

The Academy gave the Marx gold medal to Suslov and he responded with an address: "Our Epoch—the Epoch of Celebration of Marxism-Leninism." After devoting most of his address to a paean on Marxism-Leninism, to support of "proletarian internationalism" and an attack on "right and left revisionists, Maoists, and nationalists of various hues," he turned to the role of science and technology in the Soviet state. He ended his address as follows:

> The contemporary scientific-technological revolution opens before society unseen possibilities in using science for mastering and protecting the forces of nature and solving social problems. This revolution discloses the deep anti-humanitarian character of the capitalistic system, sharpens all its contradictions and at the same time acts as material preparation for communist civilization.

* Data on Zimyanin is as follows: After party work, he joined the apparatus of the Foreign Ministry (1957–60), was ambassador to Hungary in 1956–57, to Czechoslovakia in 1960–65, and in 1965 deputy foreign minister. From September 1965 he was editor of *Pravda*; member of the Party since 1939; member of the Central Committee from 1952–56.

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Institutions of Higher Learning

The universities in the Soviet Union, as in the other countries of the world, are not only institutions of higher education but also centres of basic research and scholarship. In the Soviet Union, their role in research is much smaller than that of their counterparts in the West. Most of the research in the Soviet Union is carried out at the institutes. There is some interlocking between the universities and the research institutes in that leading scientists of the latter teach and supervise graduate research at neighbouring universities. The forty universities can be divided into several groups: the old universities with established world-wide reputations of scholarship (Moscow, Leningrad, Kiev, Kazan, Kharkhov); a second group of universities that have the right to award both the doctor of science and *Kandidat* degrees and can be considered as basic research centres (Azerbaidzhan, Belorussian, Dnepropetrovsk, Erevan, Kazakh, Latvia, Lvov, Tashkent, Odessa, Rostov, Saratov, Tartu Tbilisi, Tomsk, Vilnyus, Voronezh), and the remaining which are of minor importance as research centres.

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The Role of the Academy of Sciences [1]

Loren R. Graham

ALMOST all observers of the Soviet Union are familiar with the special place which the Academy of Sciences of the USSR occupies within the general framework of Soviet science and education. Indeed, if one were to ask "What is the largest single difference between the organization of science in the United States and in the Soviet Union?" the answer would surely be that while in the United States the larger part of fundamental research is performed in the universities, in the Soviet Union fundamental research is predominantly located within the Academy system.

Our attention is attracted to the Academy of Sciences of the USSR for reasons that are both contemporary and historical in nature.[2] The Academy is the only one of the learned societies founded in the seventeenth and eighteenth centuries which continues today to dominate science within a major industrial country. Indeed, it is probably no exaggeration to say that the Academy of Sciences of the USSR is the most important single scientific institution in the world, since in those countries which equal or surpass the Soviet Union in quality of science or overall scientific effort, fundamental research is dispersed throughout a variety of autonomous universities and institutions, both public and private.

Outside the Soviet Union there has been considerable speculation in recent years that the Soviet Academy is beginning to lose some of its earlier influence and autonomy. In the wake of the reforms of Soviet science in the late fifties and early sixties, Alexander Korol wrote that the Academy had been seriously downgraded.[3] A noted American scientist who recently returned from Moscow observed that a long-term

[1] Much of the information in this article was gathered during a trip I made to the Soviet Union from 19 Sept. to 2 Oct. 1976, as a member of a Working Subgroup for the Joint US-USSR Study of Fundamental Science Policy under the chairmanship of Dr Harrison Shull of Indiana University. I also gained information from conversations with members of the staff of the Commission on International Relations of the National Academy of Sciences. Preliminary versions of this paper were presented at the Programme on Science and International Affairs, Harvard University, and the GWU/NSF Workshop on Soviet Science and Technology, Airlie House, Virginia, 18–21 Nov. 1976. I am grateful to these organizations and individuals for assistance.

[2] For general discussions of Soviet science policy and the origins of the organizational characteristics of Soviet science, see E. Zaleski, et al. *Science Policy in the USSR* (OECD, Paris, 1969); my "The Development of Science Policy in the Soviet Union," in T. Dixon Long and Christopher Wright (eds.), *Science Policies of Industrial Nations* (Praeger Publishers, New York, 1975), pp. 12–58; and my "The Formation of Soviet Research Institutes: A Combination of Revolutionary Innovation and International Borrowing," *Social Studies of Science*, No. 5, 1975, pp. 303–329.

[3] Alexander Korol, *Soviet Research and Development* (MIT Press, Cambridge, 1965), especially p. 36.

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and probably fatal decline of the Academy of Sciences had begun. Some American scientists have spoken about serious competition to the Academy from other Soviet organizations, especially from the State Committee for Science and Technology. Other Western observers have considered it inevitable that Soviet universities would gain in scientific influence at the expense of the Academy, with the result that the organization of Soviet science would become progressively similar to the organization of science in the United States.

Against this background, questions about the continuing role of the Academy of Sciences, of recent changes in its organization, and of expectations for its future would appear to be of considerable interest to scientists and science administrators everywhere. Therefore, in this article I will examine recent events in the Academy's history and trends in its development in order to try to assess its past and probable future. My approach will be to identify, first, several factors which appear to be diminishing the importance of the Academy in the general framework of Soviet science, and secondly, those factors which continue to strengthen its influence. Finally, I shall attempt to appraise the relative weight of these contradictory trends and give conclusions about the present status of the Academy.

I. Factors Diminishing the Role of the Academy

1. The State Committee for Science and Technology

The single most important recent change in the organization of Soviet science and technology is quite clearly the rise in influence of the State Committee for Science and Technology, a body charged with working out a single scientific-technical plan for the entire Soviet Union. The importance of the State Committee is revealed in part by the fact that while the President of the Academy of Sciences of the USSR, A. P. Alexandrov, serves as a member of the Council of Ministers of the USSR, the Chairman of the State Committee, V. Kirillin, is not only a member but vice-chairman of the Council of Ministers.

The State Committee for Science and Technology is a fairly new organization, founded in 1965. It is true that before 1965 there existed a somewhat similar committee, the State Committee for the Coordination of Scientific Research Work, founded in 1961, and a series of antecedent committees stretching all the way back to the immediate post-second world war years (*Gostekhnika, et. al.*). The important fact, however, lies not in these bureaucratic details, but in the impressively increasing influence of these antecedents and, especially, of the State Committee. In the late forties and fifties these committees concentrated primarily upon specific applied science projects, such as canal design and construction, and assistance to the cotton industry.[4] In these

[4] Discussion with E. L. Skliarov, Deputy Chairman of the State Committee on Science and Technology, Moscow, 1 Oct. 1976.

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early years the committees were little concerned with science *per se*, leaving it almost entirely to the Academy of Sciences.

In the sixties, however, a new appreciation of the role of science as a source of technical progress grew in step with several economic and bureaucratic changes in the Soviet Union, with the result that the State Committee began to give greater and greater attention to science as well as technology, and to the elaboration of all-union science policy. In connection with the economic decentralization reforms espoused by Nikita Khrushchev, the Academy of Sciences of the USSR decentralized its work (the Siberian department of the Academy was founded in these years) and began to concentrate more and more on fundamental research, shedding a number of its applied institutes. Concerns with industrial applications passed more and more from the Academy to the industrial ministries. The State Committee developed as the one place in the Soviet Union where *both* science and technology were viewed within the framework of a national plan.

At the present time the State Committee is still a relatively small organization compared to the Academy, with a permanent staff of about 600, but its influence is already very great throughout the entire Soviet research and development establishment. In its system of sub-committees and scientific councils (*nauchnye sovety*) the State Committee obtains the voluntary assistance of thousands of Soviet scientists, including almost all the members of the Academy of Sciences. The advisory role of these scientific councils is reminiscent of the committees of the National Research Council in the United States, but an important distinction is that above this advisory level of its scientific councils the State Committee itself has executive authority, particularly when a jurisdictional conflict over technology arises among several industrial ministries. Furthermore, the State Committee has a unique responsibility for planning applied research. Its concerns and authority transcend the applied research realm, however, since it must approve the entire research and development budget, including the gross figures for the Academy of Sciences' budget, the internal structure of which is left to the Academy. (The Academy also retains final authority in the direction of fundamental research.) The State Committee periodically compiles a list of the current 200 to 250 most important scientific-technical problems facing the country and works with the State Planning Committee (*Gosplan*) in seeking their solution.

The State Committee for Science and Technology is also an important funding agency. Each year it is assigned a large "reserve fund" consisting of 2 to 3 per cent of the entire Soviet R & D budget which it disperses as it wishes to research organizations throughout the Soviet Union, whatever their formal or bureaucratic affiliations may be. In a visit to the Soviet Union in September and October of 1976, I was told that the State Committee is quite important to institutes of the Academy of Sciences as a place for appeal for extra funds for research.

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There is no question that the State Committee for Science and Technology has acquired some of the authority earlier exercised by the Academy of Sciences, especially by its now disbanded Division of Engineering Sciences. In recent years the State Committee has even acquired a few research institutes of its own, either under its unique authority or under dual jurisdiction, such as the Institute of Technical Aesthetics, the All-Union Institute of Scientific and Technical Information, the Institute of Problems of Control, and the All-Union Information Centre.[5] The latter organization, a recent innovation, is charged with registering all research in the Soviet Union, wherever it is performed, is empowered to ask for reports from any institute, and is charged with avoiding duplication of research by several institutes.

A look at the few institutes directly under the State Committee shows that they are all of a general, primarily informational character, and do not include what working scientists or engineers would call laboratory research.[6] This sort of work is still located primarily in the three large pyramids of industrial ministries, universities, and academies of sciences (All-Union and republic). The State Committee interferes least of all in the execution of fundamental research in the natural sciences, where both direction and allocation of funds is largely in the hands of the Academy.

2. *The removal of institutes from the Academy of Sciences*

In connection with the increasing concentration of the Academy of Sciences of the USSR on fundamental research, a rather large number of institutes concerned with industrial research were transferred in the early sixties from the Academy to industrial ministries. According to Soviet sources, the Academy of Sciences of the USSR lost over 40 per cent of its scientific establishments in 1961.[7] In 1960 the Academy of Sciences of

[5] The Institute of Technical Aesthetics was formed as a result of complaints from foreign buyers that Soviet technology, while often quite adequate from an engineering standpoint, suffers in foreign competition because of its unattractiveness.

[6] There have been a few proposals in the Soviet press that the State Committee take over direct responsibility for the industrial research institutes and become a sort of "Academy of the Engineering Sciences." If such a step were taken, it would mean a radical shift in the organization of Soviet science and the place of the present Academy of Sciences of the USSR. This change seems unlikely, however, since it would separate applied research from close industrial contact even more than is presently the case. For a discussion of such a proposal, see A. Zalkind, "Akademiya—dlya 'neakademicheskikh" nauk," *Literaturnaya gazeta*, 24 Mar. 1976; discussion of this article in "Akademiya—dlya 'neakademicheskikh' nauk," *Literaturnaya gazeta*, 21 Apr. 1976; "Akademiya—dlya 'neakademicheskikh' nauk," *Literaturnaya gazeta*, 9 June, 1976; V. Rassokhin, "Rol' lidera obiazyvaet," and Ia. Kolotyrkin, "'Akademiya' . . . v ministerstve," *Literaturnaya gazeta*, 28 July, 1976; L. Vereshchagin, "Instituty? Net, zavodskie laboratorii," *Literaturnaya gazeta*, 18 Aug. 1976; A. Kitaigorodskii, "Tsena issledovaniya," *Literaturnaya gazeta*, 8 Sept. 1976. I am grateful to Professor Thane Gustafson, Department of Government, Harvard University, for copies of these articles.

[7] *Narodnoe khozyaistvo v 1962 g., Statisticheskii Ezhegodnik*, Moscow, 1963. See also President Keldysh's report on removal of applied institutes in *Pravda*, 13 June 1961. I am grateful to Mr John Löwenhardt of the University of Amsterdam for information on these transfers.

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the USSR possessed over 240 research establishments, but by 1962 this number had dropped to somewhat over 160. A result of this decrease was a loss in relative terms of the influence of the Academy within the overall framework of Soviet science. In the late sixties, however, the Academy began growing by adding institutes in the fundamental sciences and in the early seventies surpassed the peak set more than a decade earlier. At the present time there are approximately 250 research establishments in the Academy of Sciences of the USSR, a figure which does not include the institutions of the republic academies (adding them would bring the total for the whole Academy system to over 600). In the meantime, however, the overall dimensions of Soviet research and development continued to grow, particularly in the industrial sector, and many observers would maintain that the place of the Academy, relatively speaking, does not equal today what it was 20 years ago.

The removal of the industrial research institutes from the Academy in the early sixties was not an action that was forced on the Academy, but a reform that was strongly supported by an influential group of Academy members working in the basic sciences, particularly chemistry. physics and mathematics.[8] These scientists wanted to correct what they saw as an exaggerated emphasis on applied research during the Stalinist period. To them, the removal of the applied institutes was a logical reform that would improve both the Academy and Soviet science.

Many years have now passed since that reform, and it becomes increasingly clear that while the scientists interested in basic science achieved their major goals, they also increased the vulnerability of the Academy to criticism from the outside. The unity of theory and practice has always been an important slogan in Soviet ideology; with very few applied institutes, the Academy could now be accused of not adhering to this principle. The Academy tried to head off this criticism by pointing to the many services which it continued to provide for industry, and by supporting a system of contract research between Academy institutes and industries. The problem of the transfer of fundamental research to industrial application remains, however, a very difficult one in the Soviet Union, and the Academy may encounter increasing criticism because of its post-reform emphasis.

3. The increasing role of foreign technology, bilateral governmental agreements, and contracts abroad

In recent years the purchase of foreign technology through economic agreements with Western companies and the conduct of cooperative research based on governmental bilateral agreements have become increasingly important aspects of Soviet science policy. In these activities the State Committee has occupied a much larger place than the

[8] On the reform of the early sixties, see my "The Reorganization of the Soviet Academy of Sciences," in Peter Juviler and Henry Morton (eds.), *Soviet Policy-Making* (Frederick J. Praeger, New York, 1967), pp. 133–61.

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Academy of Sciences. Indeed, the State Committee is directly responsible for negotiating contracts with foreign companies.

The Academy of Sciences has a foreign department which conducts exchange programmes with academies of sciences of other nations, but these types of exchanges have become less visible and important in recent years as direct bilateral governmental exchanges have grown in influence. Thus, the Soviet government has concluded a whole series of bilateral agreements with the United States since 1972; most of these projects for joint research are goal-oriented and therefore the Soviet Academy of Sciences, the seat of fundamental research, has not been as important in their elaboration and execution as the State Committee.[9] Of course, the small but important inter-academy exchange between the United States and the Soviet Union has continued throughout this period, but it has attracted much less attention than the newer bilateral agreements. The impression has been created in both the Soviet Union and the United States that the State Committee and the ministries have been more active in international science and technology than the Academy of Sciences.

Another danger to the Academy that is contained in the emergence of the State Committee as the purchaser of foreign technology, concerns military research. The Academy has always performed important research for the Soviet military establishment, but the ratio of military to non-military contracts in the Academy may be increasing as the success of the Soviet Union in acquiring non-military technology abroad grows. A long-term development in this direction might affect the character of the Academy's institutions.

4. The influence of the civil rights and dissidence movement and of ideological difficulties

The Soviet Academy of Sciences has provided employment or protection for a rather large number of Soviet civil rights activists, dissidents, and ideological non-conformists, a fact that increases governmental uneasiness and suspicion. Despite Academician Sakharov's long campaign on behalf of human rights, he is still a full member of the Academy, enjoying its rights and privileges. Although many of his fellow academicians signed a letter criticizing him, not all who were asked to sign did so, and the absence of a few signatures is one more sign that the Academy of Sciences of the USSR still possesses a larger measure of autonomy than any other institution of the USSR. Of course, those Western observers are correct who say that all science in the Soviet Union is governmental science, but this remark misses the cardinal point that not all governmental science in the Soviet Union is the same.

[9] For a discussion of these bilateral agreements, see *US–USSR Cooperative Agreements in Science and Technology: Hearings before the Subcommittee on Domestic and International Scientific Planning and Analysis of the Committee on Science and Technology* (US House of Representatives, US Government Printing Office, Washington, DC, 1976).

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Along the spectrum of controls that exist in world science, the Academy of Sciences of the USSR is closer to that end that might be labelled "academic freedom" than any other institution in the USSR. Plenty of controls remain, but no member of the Academy has been expelled since the death of Stalin, a record of importance to prominent non-conformists. The fact that Troffim Lysenko, despised by most of the leading academicians, was until his death in November 1976 a full member of the Academy is ironically an expression, at least in part, of the knowledge by the other academicians that expulsion is a double-edged sword that could be used against honest but non-conformist academicians as well as the fraudulent Lysenko.[10] Although Academy rules provide for the expulsion of a member if he or she engages in anti-Soviet activity, in practice membership is considered a sacred, irrevocable privilege awarded by secret ballot.

The measure of autonomy and occasional unorthodoxy exercised by the Academy and its institutions has elicited criticism from the Communist Party, although it would not be accurate to describe their relationship as one of hostility. Most academicians long ago made their peace with the political authorities, and quite a few of the administratively influential ones are members of the Party. President Alexandrov is a member of the Party Central Committee. The fact still remains, however, that the conservative members of the political establishment view the Academy more suspiciously than they do the State Committee or the industrial research establishment. In recent years several important Academy research institutions have come under ideological criticism, including the Siberian Department of the Academy of Sciences and the Lebedev Physics Institute.

At the 24th Party Congress in 1971 the Party statutes were revised to give Party organizations in fundamental research institutions greater control over research administration. The effects of this change in the statutes were felt primarily in the Academy of Sciences. Paragraph 60 of the Party statutes had earlier exempted non-industrial (academic) research institutes from administrative control by the primary Party organizations.[11] The new statutes applied the same rules to academic institutions as industrial ones, a change which reflects the Party's desire to exercise greater supervision over the Academy of Sciences. The actual significance of the change, however, is still uncertain.

5. The levelling-off in graduate education

One of the most clear recent changes in Soviet science and education has

[10] On Lysenko, see Zhores Medvedev, *The Rise and Fall of T. D. Lysenko* (Columbia University Press, 1969); David Joravsky, *The Lysenko Affair* (Harvard University Press, 1970); Mark Adams, "Genetics and the Soviet Scientific Community," Ph.D. thesis, Harvard University, 1973, forthcoming as a book; and my *Science and Philosophy in the Soviet Union* (Alfred A. Knopf, New York, 1972).

[11] *Partiinaya zhizn'*, No. 9, May 1971, p. 12. A discussion of this change may also be found in Mose L. Harvey, Leon Gouré, Vladimir Prokofieff, *Science and Technology as an Instrument of Soviet Policy* (University of Miami, Miami, 1972), p. 82.

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been a levelling-off in the number of graduate students in all fields, including the sciences. The implications of this development for the mutual relationships of the three main parts of the Soviet R & D establishment—the industries, the Academy and the universities—are not yet apparent, but it seems likely that the latter two will be more seriously affected than the first.

Recent statistics on Soviet graduate education show a levelling-off in total number in the late sixties and even a small absolute decline in the early seventies. Statistics taken from Soviet sources are as follows [12]:

Total Number Graduate Students (*aspiranty*) by years

1940	*1950*	*1960*	*1965*	*1968*
16,863	21,905	36,754	90,294	98,139
1970	*1971*	*1972*	*1973*	*1974*
99,427	99,308	98,945	98,860	96,939

These statistics show a staggering increase in the number of Soviet graduate students in the five-year period between 1960 and 1965—an increase of two-and-a-half times—and a remarkably stable situation since then.

At the same time that levelling-off of graduate student enrolment was occurring, Soviet industry was continuing to expand, although less rapidly than earlier. At first glance, at least, these trends seem to indicate a relative decrease in academic science compared to industrial research. Before reaching this conclusion, however, one should note that the trends have not continued long enough to warrant extrapolation, and there exist pieces of contradictory information.

One factor which complicates interpretation of these statistics is that the Academy is increasingly using another method of preparing personnel that does not show up in this analysis. This growing source of advanced degrees is *soiskatel'stvo*, a word that cannot be satisfactorily translated, but which might be best described as "degree work by external application." *Soiskatel'stvo* is the following method of application for an advanced degree: a person who is working in a research institute on salary, and who is not a graduate student on scholarship, may apply for the degree of *kandidat* (usually equated with the US Ph.D. degree) on the basis of his or her completed research work. In order to ensure broad knowledge, such a person must also pass an examination. If the outside applicant is successful in his examination and application, he may be awarded the degree on the basis of this lateral entry. In the Siberian Department of the Academy of Sciences there are already twice as many people working for their degrees in this way as through

[12] Primary sources for these data are *Narodnoe Khozyaistvo: Statisticheskii ezhegodnik* for the relevant years. For the early years also see Nicholas DeWitt, *Education and Professional Employment in the U.S.S.R.* (National Science Foundation, Washington, DC, 1961).

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normal graduate study (*aspirantura*).[13] Senior research scientists there praise the quality of scholars produced in this way. Novosibirsk and *Akademgorodok* appear to be unusual in their emphasis on *soiskatel'stvo*, but the experiment is being watched elsewhere.

In view of the uncertainty about the meaning of graduate student statistics, it is probably premature to conclude that the levelling off of enrolments is seriously and differentially affecting the Academy of Sciences, although Soviet authors themselves have written that, " Naturally, the tempo of growth of scientific workers and the expenditures on science can not be long preserved on the levels they have been during the last two decades." [14]

The above factors, which tend to diminish the role of the Academy in the total picture of Soviet research and development may appear to be overwhelming in their totality. On the basis of these factors, some people may conclude that the Academy is truly in decline. In my opinion, however, such a conclusion would be hasty. There are other factors, almost equally strong, which continue to sustain the pre-eminence of the Academy. These sustaining factors are not as concrete as the pressures on the Academy from external elements and therefore less easy to identify and less visible to foreigners, but they are nonetheless very powerful indeed. I shall discuss a few of them below.

II. Factors Sustaining the Role of the Academy

1. The quality of research in the Academy system and the Academy's position in fundamental research

The Academy of Sciences is without question the organizational focus of the best quality of fundamental research performed in the Soviet Union. Almost all observers, both inside and outside the Soviet Union, agree that the Academy is the most creative institution in Soviet science, even if these same observers may emphasize flaws that exist throughout Soviet science. There are exceptions to the pre-eminence of the Academy, of course—mathematics in Moscow and Leningrad universities, atomic research in the Kurchatov Institute (which belongs to the State Committee on Atomic Energy), several institutes in industrial ministries—but the qualitative edge of the Academy over most other Soviet institutions is as clear today as it was 20 years ago. The prestige which flows from this simple fact is difficult to overestimate. The Academy may have slipped in its influence as a science policy-making institution for the Soviet Union as a whole, but it is still the place to go when one is seeking the best Soviet researchers and theorists in almost any field.

Furthermore, none of the above trends is seriously undermining the qualitative edge of the Academy. The State Committee for Science and

[13] Conversation with G. I. Marchuk, President of the Siberian Department, USSR Academy on Sciences, Novosibirsk, 23 Sept. 1976.

[14] S. Mikulinskii, " Problema nauchnykh kadrov v usloviyakh nauchno-tekhnicheskoi revoliutsii," *Kommunist*, No. 5, 1973, p. 77.

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Technology has no institutes in fundamental research and is planning none. The removal of applied research institutes from the Academy in the early sixties diminished the role of the Academy in industry, but the change allowed the Academy to concentrate on what it does best, and therefore increased its already strong sense of identity. As Academician L. A. Artzimovich remarked at a meeting of the Presidium of the Academy of Sciences shortly after those reforms [15]:

> The question about whether we should give greater attention to semi-conductors and electronics or to astro-physics is a special case of a more general problem: should the Academy primarily play the role in our government of a first-aid ambulance for scientific-technical assistance, or should it serve its primary goal—the development and support of those fundamental researches whose usefulness is outside the time framework usually employed in economic planning? The latter seems to me to be the more correct approach.

2. The quality of leadership of the Academy

The Academy of Sciences has been fortunate throughout its history during the Soviet period in having a series of leaders of exceptional quality who devoted themselves to advancing its interests. When I speak here of the top leadership, I mean not only the presidents of the Academy (Karpinsky, Komarov, Vavilov, Nesmeianov, Keldysh, Alexandrov), but a host of scholar-administrators at the vice-president, scientific secretary, division and institute levels who have repeatedly demonstrated their ability to solve both administrative and intellectual problems involved in promoting research to a degree not matched by the administrators in other parts of the Soviet scientific bureaucracy.

This tradition of strong and intelligent leadership was established in the 1920s, when the place of the Academy in Soviet science was much more uncertain than it is at the present time. The Academy in the early twenties was a small organization in which there were no academicians who were also members of the Communist Party. Most of the members had little enthusiasm for the Soviet order. Outside the Academy several militant groups described it as a vestige of the *ancien régime*, and called for its abolition, as the *Académie Royale des Sciences* in Paris had been abolished in the wake of the French Revolution. Lenin gave the Academy important support on several occasions, but he died in 1924, long before the pattern of Soviet research was set.

Against this background, the leaders of the Academy in those years—President Karpinsky and especially Permanent Secretary S. F. Ol'denburg—adopted the policy of proving the value of the Academy to the Soviet regime by simply out-performing all its competitors—the universities, the new Communist Academy, the branch and ministerial organi-

[15] " Sistema stimulirovaniya razvitiya fundamental'nykh issledovanii v SSSR," p. 39, report submitted by Soviet Working Subgroup during discussions in Moscow in Sept. 1976, under the Joint US-USSR Study of Fundamental Science Policy.

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zations. The Academy gradually assumed a large number of practical tasks which the government wished to have performed, and it was able to attract the necessary talent to solve a number of the problems.[16]

Eventually the Academy was fully integrated into the Soviet system, but the tradition of intellectual quality and adroit leadership has remained. Even today the visitor to scientific institutions in the Soviet Union often catches the sense of pleasure shown by administrators of the Academy when they are able to demonstrate to the foreign scientist that the best Soviet work in his field is in the Academy system and when they succeed in making the bureaucratic arrangements necessary for a visit more rapidly than the more ponderous ministerial and educational bureaucracies.

3, The strength of the Academy "idea"

Connected with the quality of Academy leadership is the deep reservoir of support which the Academy system has from working scientists. Despite the many flaws of the Academy system—low mobility, political interference, continuing problems of scientific supply and instrumentation, domination of the younger scientists by the older ones—Soviet scientists are very much aware that it provides better and freer conditions of work than anywhere else in the country. Defence of the interests of the Academy is a popular cause in the Soviet Union, one on which both leading establishment scientists and non-conformists or dissidents are likely to agree, each, perhaps, for their own reasons. The establishment scientists are eager to defend the quality of scientific research in the Academy and the privileges which they receive from being connected with it. The non-conformists recognize the protection that the Academy occasionally has given them, or at least the symbolic importance that individual academicians such as Sakharov have for the human rights movement. The Academy has its critics among scientists, especially in the industrial, agricultural and educational establishments, as well as a few dissident scientists who criticize it for being so integrated into the Soviet system—but the predominant opinion among Soviet intellectuals seems to be that the differences between the Academy and the rest of the research establishment are important ones that should be preserved. Whether one is interested primarily in promoting intellectual quality or defending those areas of relative political autonomy which exist in the Soviet Union, the Academy is a precious institution to the Soviet intelligentsia. This alliance of establishment and non-establishment sentiment is rare among intellectuals in the Soviet Union, and is one of the hidden strengths of the Academy.

[16] For a discussion of these years, see my *The Soviet Academy of Sciences and the Communist Party, 1927–1932* (Princeton University Press, 1967), and my "Science in the Russian Revolution," in Everett Mendelsohn and Thomas Glick (eds.), *Science and Revolution* (D. Reidel, Boston, forthcoming).

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4. The expansion of the Academy's realm of activities

The list of factors tending to diminish the importance of the Academy given in the first part of this article may have created the impression that the Academy is everywhere on the defensive. Any such impression can be countered by noting that in several areas, and especially in the area of advanced education in the sciences, the Academy in recent years has been increasing its influence.

The main organizational features of Soviet science education were established in the period from roughly 1930 to 1950. The universities were assigned primarily a pedagogical function, while the Academy and the ministerial systems were the places where advanced research was usually performed. This separation of research from teaching was never absolute—many researchers also taught in universities—but compared with countries like Great Britain and the United States, the separation of the realms was striking.

In the pre-reform discussion period in the late fifties, many Soviet scientists commented that this division of functions had been carried too far and that it was time to create closer links between leading research scientists and bright students, graduate and undergraduate. American scientists who heard of these discussions often assumed that the eventual result would be a strengthening of research science in the universities themselves, a relative diminution of the role of the Academy in its near monopoly in high quality fundamental research, and a closer approximation of the Soviet system of scientific research to the American model. In bureaucratic terms, this would have meant a growth of the scientific significance of the Ministry of Higher and Secondary Specialized Education, a part of the Soviet government quite separate from the Academy of Sciences.

A number of reforms directed towards strengthening the links between research and teaching have been enacted in the Soviet Union. Some of them have achieved this goal by increasing the funds for university research facilities, and the role of research in Soviet universities has definitely grown. The most striking reforms have, however, achieved the same goal by working in the opposite direction: instead of moving some of the advanced research out of the Academy into the universities, the best scientific research in the universities has been brought more and more under the influence of the Academy.

The place where this development has reached its highest form is Novosibirsk, where the University of Novosibirsk is almost literally a part of the Siberian Department of the Academy of Sciences. The creation of a new type of university under the Academy was an important part of the plans for Novosibirsk from the very beginning of the Academic City (Akademgorodok) in 1957. The first leaders of Akademgorodok, especially Academician M. A. Lavrentiev, were critical of Soviet universities, where they thought the level of scientific research was low. One of the reasons for the founding of Akademgorodok in Novosibirsk

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rather than in Irkutsk was the absence of a university in Novosibirsk and hence the possibility of starting *de novo*, of creating a new model university which would be under the strong influence of the Academy of Sciences rather than the Ministry of Higher Education.

The first principle of the University of Novosibirsk was that there should be no full-time faculty, only faculty members who were also researchers in the institutes of the Siberian Department of the Academy of Sciences. The selection of students for entry into the University is exceedingly rigorous, and is controlled by the Academy of Sciences through its system of Siberian "Olympiads," a series of tests given in secondary schools. The teacher-student ratio at the university is high, 1,000 research professors and 3,500 students. Once in the university, every student is expected by his third year to be doing research in an institute of the Academy of Sciences, and in his fourth year, the student spends four days a week at the Academy. When the time for advanced graduate work arrives, the student is ready for complete transfer to an institute of the Academy, where he is already well known. Thus, the Academy is in control of the entire process of education, from undergraduate admission to entry into graduate study, as well as graduate study itself.

Establishing such a system required that a special agreement be worked out between the Siberian Department of the Academy of Sciences and the Ministry of Higher and Secondary Specialized Education, which is normally in charge of university education. Whether the Ministry resisted this incursion into the realm of its normal authority is not known. Evidence of the compromise that was reached can be seen in the method by which the rector of the University of Novsibirsk is chosen: He is nominated by the Siberian Department of the Academy of Sciences, but actually appointed by the Ministry of Higher and Secondary Specialized Education.

This system of university and graduate education in Novosibirsk is unique, but in both Moscow and Leningrad the influence of the Academy of Sciences upon education is heavy, and probably growing. One of the first institutions in the USSR to overcome significantly the division between research and education was the Moscow Physical-Technical Institute, founded in 1951, a place where research scientists were in charge of education. Several of the scientists who founded the Siberian Department of the Academy of Sciences, including Academician Lavrentiev, had been founders and teachers in this institute, and it served, in part, as a model for them when they moved to Siberia.

At Moscow and Leningrad universities, each of which has its own traditions, the Novosibirsk model is not appropriate. Here also, however, the Academy of Sciences found ways to extend its influence. Many of the academicians and leading researchers in the Academy also have connections with the universities. When they identify bright and promising young students at the university, they often invite them to participate in research in the institutes of the Academy which, like the univer-

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sities, have the power to award advanced degrees. The negative side of this process is that the universities have difficulty building up an independent research system of high quality, since the Academy often takes their best students. The positive side is that the Academy is able to maintain its high standards, a necessary condition for its continuing role in Soviet science.

One other recent development in Soviet education points to a further loss of influence of the Ministry of Higher and Secondary Specialized Education in advanced degree work and the growth of the other divisions of the research establishment. Until early 1976, the Higher Attestation Commission (VAK), which is in charge of certifying degree candidates, was a part of the Ministry of Higher Education. A special resolution of the Party Central Committee and the Council of Ministers removed VAK from the Ministry and established it as a separate commission under the Council of Ministers.[17]

5. *The commitment of the Soviet government and society to fundamental research*

On a recent visit to the State Committee for Science and Technology in Moscow, I told E. I. Skliarov, vice-chairman of the committee, that many American scientists believed that the State Committee had in recent years gained influence at the expense of the Academy, and that a few of them even thought that the Academy had entered a period of long-term decline. Mr Skliarov sharply disputed this view, replying that the best evidence for the continued, even increasing, influence of the Academy is the fact that during the last few years the rate of growth of the budget of the Academy of Sciences has been higher than the rate of growth of the budget for research and development in the Soviet Union as a whole. Although Mr Skliarov did not give absolute figures to support this statement, I found that other Soviet science administrators, both inside and outside the Academy, agreed that the observation was correct. In recent years the number of Academy institutions has grown impressively. The overall budget has also increased rapidly, as Mr Skliarov emphasized, and several institute directors remarked that many of the financial additions in recent years have been put into better equipment, instrumentation and supplies rather than personnel increases, a change from earlier years. The present policy of the Academy is to improve the quality rather than the quantity of its work, and in that way to strengthen the Academy further in the area where it is already strong.

The commitment of the Soviet government and of Soviet society to the support of fundamental research seems to be firm, and the Academy is the primary beneficiary of that largesse. In some other countries, especially in the United States, there has been talk in recent years of a " turn away from science " and a relative loss of popular support for

[17] *Pravda*, 9 Nov. 1974; *Pravda*, 18 Jan. 1976.

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science, a development that would obviously be more significant in a democratic society than in an authoritarian one. In the United States, where massive public support for fundamental science is only about a generation old, there is some danger that the criticism of science which in its early manifestations is primarily an economic one, might tap older roots in American traditions hostile to abstract theory in general, a re-birth of the anti-intellectualism in American popular attitudes, that historians such as Richard Hofstadter have described in detail.[18]

The older traditions in Russian society are perhaps somewhat more congenial to what used to be called " pure science." In the late nineteenth century, when American science was largely utilitarian in nature, Russian science already had a small but fine tradition in theoretical work, especially in mathematics, but also in chemistry and physics. That old tradition, combined with the more recent scientism inherent in contemporary Soviet culture, may give fundamental science a rather large reservoir of support, at both official and unofficial levels. It is interesting to note that even many of the outspoken critics of Soviet society—one thinks of Sakharov, Zhores Medvedev, Valentin Turchin—have continued to share the assumptions of Soviet culture about the validity of a scientific world view, and the importance of science as a formative element in culture.[19] An exception here may be Alexander Solzhenitsyn, who has sharply criticized scientism in some of his writings; it is also likely that similar unpublicized criticism of science exists among other segments of Soviet society, particularly among religious groups and among some parts of the literary intelligentsia, those people who have been increasingly dismayed by the incursions of technology upon traditional Russian village life.[20] All available evidence indicates, however, that science is still widely regarded in the Soviet Union as a progressive force of great untapped potential; indeed, a defence of enlightenment in eighteenth century terms is probably more popular among intellectuals in the Soviet Union than in Western countries, where the appeal of this model has lost some of its earlier force.[21]

[18] Richard Hofstadter, *Anti-intellectualism in American Life* (Alfred A. Knopf, New York, 1963).

[19] See, for example, Andrei Sakharov, *Progress, Coexistence, and Intellectual Freedom* (W. W. Norton, New York, 1968); Zhores Medvedev, *The Medvedev Papers* (Macmillan, London, 1971); Valentin Turchin, *The Phenomenon of Science* (Columbia University Press, New York, 1977).

[20] For a particularly strong criticism of science, see Alexander Solzhenitsyn, *Candle in the Wind* (Minneapolis, 1973). For an interpretation of Soviet intellectual life that sees the major split as not between the familiar " two cultures " (scientific-technical and literary-humanities) as in the West, but between the " scientific-cultural " and the " technical-economic," see Arnold Buchholz, " Die Rolle sowjetischer Naturwissenschaftler im Entscheidungsprozess," in Boris Meissner and Georg Brunner (eds.), *Gruppeninteressen und Entscheidungsprozess in der Sowjetunion* (Verlag Wissenschaft und Politik, Köln, 1975), pp. 211–232.

[21] Dr Mark Kuchment, jointly sponsored by the Russian Research Center, Harvard University, the Russian Institute, Columbia University, and the Ford Foundation, is writing a study of Soviet attitudes toward scientific enlightenment. I am grateful to him for conversations on this topic. For further opinion on Soviet attitudes toward science,

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III. Conclusions

In assessing the current position of the Academy of Sciences of the USSR in the overall organization of Soviet science, it is useful to examine its role in four different areas: (1) Science Policy Formulation; (2) Fundamental Science; (3) Applied Science; (4) Advanced Science Education. It is my opinion that the role of the Academy of Sciences has diminished in the first area, remained steady in a commanding position in the second area, decreased strikingly in the third area, and increased gradually in the fourth. These changes add up to a slight decrease in the position of the Academy, although nothing like the dramatic decline described by some Western visitors.

In the area of science policy formulation the State Committee for Science and Technology has acquired some of the influence earlier exercised by the All-Union Academy.[22] The State Committee is in charge of the overall research and development budget, and although it has been generous to the Academy, if a financial crisis occurs in the future the Committee possesses the power to curtail important aspects of the Academy's activities. It should be remembered, however, that the most influential scientists advising the State Committee are members of the Academy; on questions which involve scientific expertise the voice of the Academy will continue to be strong.

The diminishing of the role of the Academy of Sciences in science policy formulation is in many ways a process inherent in the growing scientific sophistication and diversification of the Soviet Union. In the early Soviet period, when there was a severe shortage of qualified scientists, the Academy was called upon to fulfil a wide variety of tasks, some of them much more in the realm of engineering than in science. Lenin, for example, turned to the Academy for help in industrial reorganization in the first years of the Soviet government, a task for which a host of other Soviet institutions are now more appropriate.[23] As these other

see Jerome R. Ravetz, *Scientific Knowledge and its Social Problems* (Oxford, 1971), p. 410, and my forthcoming " Science, Soviet Socialism and the Good Society," in Lyman Legters (ed.), *Socialism and the Good Society*.

[22] It is also possible that the specialists in science policy, the *naukovedy*, have acquired some of the influence earlier exercised by natural scientists, although this development is still limited. For discussions of the influence of the *naukovedy*, see Linda L. Lubrano " Soviet Science and Specialists: Professional Roles and Policy Involvement," in Richard B. Remnek (ed.), *Specialists and Policymaking in the Soviet Union* (Praeger Publishers, Inc., forthcoming), and her *Soviet Sociology of Science* (American Association for the Advancement of Slavic Studies, Columbus, Ohio, 1976). Also see Yakov M. Rabkin " ' Naukovedenie ': The Study of Scientific Research in the Soviet Union," *Minerva* XIV, No. 1, spring 1976, pp. 61–78.

[23] See Lenin's " Draft Plan of Scientific-Technological Works," written, it is thought, in Apr. 1918. The importance of the plan was not its immediate effects (although addressed to the Academy, it was evidently never transmitted) but the evidence it presents for assuming that Lenin thought the Academy should have a broad responsibility in the Soviet economy as well as in science and technology. A. V. Kol'tsov, *Lenin i stanovlenie akademii kak tsentra sovetskoi nauki* (Leningrad, 1969), p. 76; and E. N. Gorodetskii " K istorii Leninskogo plana nauchno-teknicheskikh rabot," in *Iz istorii revoliutsionnoi i gosudarstvennoi deyatel'nosti V. I. Lenina* (Moscow, 1960), pp. 191–232.

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institutions evolved, as the spectrum of scientific and engineering specialities increased enormously, and as the scientific and engineering work-force of the Soviet Union increased many times over, it was only natural that the Academy would play a less dominating all-union role. In the post-Stalin years the Academy has centred its attention more and more on fundamental research, while industrial research establishments have taken over most of the applied research.

There are two areas, however, where the Academy still has very prominent positions, and they add up to a powerful combination in the life of Soviet science: fundamental research and advanced science education. The core of the Academy's strength has always been in fundamental research, and its pre-eminence here remains unchallenged.[24] In advanced science education the Academy has significant competitors in the universities and polytechnical institutions, but it has been remarkably successful in extending its influence even in these institutions, while producing graduates of its own. It is probably here, in the area of advanced science education, that the eventual fate of the Academy will be decided. It is an area where its main competitor, the State Committee for Science and Technology, has little influence. If the Academy, either institutionally or through its senior personnel, can continue to guide the research of the most talented science graduate students in the Soviet Union and eventually attract the very best of them to work in Academy institutes, its prominence will undoubtedly continue. The present evidence is that the Academy is succeeding in this task.

In conclusion, then, I would observe that although the Academy of Sciences of the USSR has suffered a small decrease in influence it continues to occupy a unique and major position in Soviet science.

[24] The draft directives for the 1976–80 five year plan even contain a call "to increase the role of the Academy of Sciences of the USSR as the centre of theoretical research, as the coordinator of all scientific work in the country." P. Fedoseev, vice-president of the Academy, considered the fulfilment of this directive to be an expansion of the place of the Academy. P. Fedoseev, "Krepit sviazi nauki i praktiki," *Kommunist* No. 9, June 1976, p. 31. I am grateful to Professor Bruce Parrott, The Johns Hopkins University, for calling my attention to this reference.

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The Study of Science

Yakov M. Rabkin

SOVIET study of science or *naukovedenie* is related to the processes, institutions and protagonists of Soviet science policy making. Its subject is, among other things, science organization, planning, management and training. This makes Soviet science policy studies an important source of information on how these various elements of the research system operate in the USSR.

In this article I shall: (a) gauge the state of *naukovedenie* research; (b) assess its current trends and relate them to those prevalent in the West and in other socialist countries; (c) identify areas of possible cooperation and joint research between the US and the USSR, and (d) note certain characteristics of Soviet *naukovedenie* which may have implications for the nature of US-Soviet cooperation in this field. Working from this framework I shall also attempt to place *naukovedenie* in a wider socio-political context.

Origins

Naukovedenie as an operational concept is 50 years old. Its origins have often been associated with Marxism, although scientism seems to have been its real motive force. In a state whose legitimacy rested on "scientific communism," science had to occupy a position of prominence. Not only was science to serve as a guide in social and political transformation, but it had to be extended to improve its own performance. In 1926 the objectives and scope of the new field of research were formulated like this:

> On the one hand, it is a study of the inherent nature of science, a general *theory* of scientific *cognition*. On the other hand, it is a study of the social purpose of science, of its relations with other types of social creativity. It is something we could call a *sociology of science*. This area of knowledge does not yet exist; but it must exist: it is required by the very dignity of its object, i.e. of the revolutionary power of exact knowledge.[1]

The ideological roots of this statement are obvious. Enlarged and adroitly corrected in tune with the new times, Bacon's "knowledge is power" becomes "exact knowledge is revolutionary power." In terms of definition, *naukovedenie* has not changed since.[2] That is why

[1] I. Borichevskii, "Naukovedenie kak tochnaya nauka," *Vestnik Znaniya* 12 (1926), p. 786, emphasis in the original.

[2] More than 40 years later one reads: "The objective of *naukovedenie* is the elaboration of theoretical foundations of organization, planning and management of scientific activity, i.e. a system of measures corresponding to the inherent logic of the development of science . . . and of the increase of efficiency of research and

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it may be more appropriate to introduce the field in the words of its original proponent, rather than in those of his followers:

> First, the theory of science aims at discovering the real *tools* of scientific cognition and at discerning the *artificial tools of thought and sense* which are at the disposal of scientific thought at a given stage of its development. Secondly, it attempts to uncover the *inherent regularity* of the notions to which science could elevate itself with the given artificial tools. Thirdly, the theory of science clarifies the compulsory, necessary link between the given state of the artificial tools and the scientific truths dug out with their help. Finally, jointly with scientific sociology, the theory of science defines the distinctive nature of the *interrelationship* which links active scientific cognition with other manifestations of the social human being. The notion of science as that of a productive force is a sufficient link in this case.[3]

The new "theory of science" was later baptized as *naukovedenie* by the author. However, it disappeared from the Soviet scene soon after 1929, the "year of the great break."[4] Following the gradual demise of its potent protector, Bukharin, the small group of *naukovedenie* enthusiasts fell into official oblivion. The contradiction between the enthusiastic drive for rationalization which characterized the first post-revolutionary decade and the ruthless pursuit of politically defined goals had become too obvious. Hopes for "scientization" were acquiring the hue of personal rule during the 1930s. The practice of the social studies of science, not unlike that of any social research, was to vanish for nearly three decades.

The New Elan

Re-emerging in the early 1960s, *naukovedenie* occupied a more secure position between the exact and social sciences. Its homecoming was primarily linked with quantitative studies of science, and more generally with the science of science movement in Britain, and later in the United States. On the wave of the rehabilitation of cybernetics and sociology, *naukovedenie* established itself mainly through the efforts of exact and natural scientists. In so far as science studies are concerned, the latter command respect both in scholarly and governmental circles, and for the last 10 years they have dominated the field which is thus protected from ideological controls. After the disgrace of Lysenko and other similar instances,[5] hardly

development." S. R. Mikulinskii and N. I. Rodnyi, "Istoriya nauki i naukovedenie," *Ocherki teorii i istorii razvitiya nauki*, Moskva: Nauka, 1969, p. 59.

[3] I. Borichevskii, op. cit. p. 786, emphasis in the original.

[4] For a history of *naukovedenie* see: Y. M. Rabkin, "Origines et developpement de la recherche sur la recherche en Union Sovietique," *Le progres scientifique* 170 (mai–juin 1974), 39–51.

[5] For a detailed discussion of the interplay between science and official ideology see: G. Fisher, ed., *Science and Ideology in Soviet Society*, New York: Atherton Press, 1967.

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anyone would dare subject the natural sciences to political control. Moreover, Soviet social scientists were explicitly kept off *naukovedenie*. During the 1960s scholarship in the USSR was officially subdivided into the ideological disciplines and what would implicitly amount to the "non-ideological" sciences. Consciously isolating the former (History of the Communist Party, Marxist Philosophy, etc.) obviously served the purpose of exempting the rest of Soviet scholarship from political controls, at least as far as the content of research was concerned. Thus the RSFSR Minister of Higher Education, himself hardly a liberal, in the epilogue to the Russian translation of *The Science of Science*, which he himself edited, says that the "optimum conditions for the development of the science of science" require the acquisition of "philosophical competence" by natural and exact scientists rather than the availability of philosophers and social scientists.[6]

In fact, scientists were the most ardent proponents of *naukovedenie* during the 1960s, and institutionally the research field initially remained largely within the realm of the exact and natural sciences. The Department of Mathematical Statistics at Moscow University, the Institute of Mining in Novosibirsk and the Institute of Cybernetics in Kiev emerged as major centres of *naukovedenie* along with the Institute for History of Science and Technology in Moscow, which later established itself as the centre of the new field. Early published work in *naukovedenie* also manifested the same particularity, appearing in publishing houses or their subdivisions which specialize in exact and natural sciences. One of the more perspicacious and politically controversial books, *Naukometria* by Nalimov, was printed in the series of "Little Library of Physics and Mathematics for the Engineer," a singularly misleading cover for such a work.

What interests were the natural scientists pursuing in developing *naukovedenie*? Their most obvious motivation was to increase the efficiency of the research system through the scientization of science management. For them it meant not so much the discovery and application of certain theories of management, but the erection of defences against attempts at overt political intervention into science affairs.

Few scientists question the legitimacy of societal controls of science as such. Most hope to substitute the often arbitrary bases of such controls in the past with scientifically derived principles that *naukovedenie* should eventually formulate. Scientists are confident that science-based science policy could not but enhance their position *vis-à-vis* the political authority.

The openness of social criticism one finds in the early *naukovedenie* writings remains unparalleled in works published within the USSR. One of the reasons that scientists were allowed to criticize was the widely accepted assumption that science and scientists in the USSR

[6] V. N. Stoletov, "Posleslovie," *Nauka o nauke*, Moskva: Progress, 1966, p. 422.

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needed preferential treatment from the authorities.[7] This acceptance derives partly from the exceptional status scientists and particularly the Academy of Sciences has enjoyed in the Russian and later Soviet society, and in the eyes of the Soviet political leadership. The scientific community might be thus regarded as partially exempt from the prescribed pattern of behaviour.[8] This does not, however, necessarily lead to dissidence. Numerous scientists who departed from the "active-compliant" behaviour enjoyed relative freedom to press for particular policies *within the domain of science or science administration.* Those of them who went further on to more general issues found themselves in overt confrontation with the authorities.

In *naukovedenie* publications, scientists debated an impressive number of issues involved in the organization of the Soviet research system. One of the most sensitive problems was the dramatic disparity between the need for rapid international exchange of scientific information and the traditional control apparatus regulating the flow of information within the USSR, and from abroad. Since scientific communication is one of the better covered fields of *naukovedenie*,[9] the problem was meticulously investigated by students. The result was that the entire scientific information system came under quantitatively substantiated criticism in a series of publications: "Apparently, the core of the problem is the bad organization of our country's scientific information service—the delay in the movement of new ideas through communication channels are unacceptably long. . . . It can reach and even exceed five years. The major obstacle (responsible for the delay) is the absence of direct and regular contact with scholars abroad."[10] The authors concluded that because of the controls over information in the USSR, Soviet scientists are *a priori* disadvantaged *vis-à-vis* their Western colleagues.

[7] Similar views were expressed in certain other communist countries. Official research conducted under the auspices of the Czechoslovak Academy of Sciences yielded the following conclusion:

> Science calls for quite a different type of management, working regime, different standards and rules in society's everyday life than those suited to industry, because it involves a much higher degree of inner subjectivity and responsibility, a greater measure of initiative and self-realisation. . . . In contrast to the hierarchy of the industrial system, science reaches a state in its development where it demands a fuller implementation of democratic principles.

R. Richta, et al., *Civilization at the Crossroads*, Prague: ČSAV, 1968.

[8] cf. H. L. Biddulph, "Soviet intellectual dissent as a political counter-culture," *The Western Political Quarterly* 25 (3) 1972 (529).

[9] For accounts of developments in *naukovedenie*, see the following Soviet sources: E. M. Mirsky, "Science Policy Studies in the U.S.S.R.," *Science Studies* 2 (1972), pp. 281–294; G. M. Dobrov, "Science Policy and Assessment in the Soviet Union," *International Social Sciences Journal* 25 (3) 1973 pp. 305–325; S. R. Mikulinskii, "La Science de la Science: Problems et recherches des annees 1970," *Science Policy Studies*, Tokyo: International Commission for Science Policy Studies, 1974, pp. 186–200; as well as L. L. Lubrano, *Soviet Sociology of Science*, Columbus: AAASS, 1976, and Y. M. Rabkin, "Naukovedenie: The Study of Scientific Research in the Soviet Union," *Minerva* 16 (1) 1976, pp. 61–78.

[10] V. V. Nalimov and Z. M. Mul'chenko, *Naukometrya*, Moskva: Nauka 1969, p. 163.

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There appears to be a clear difference between the authorities' attitude towards these publications and similar findings in "extra-scientific" domains. For example, the fact that in order to get more information, Soviet scientists prefer to rely on imported sources such as *Chemical Abstracts* rather than on the Soviet *VINITI Referativny zhurnal*, is widely known within the country. A comparable finding made by sociologists with respect to the sources of political information preferred by Soviet scholars, found that "scientists in major research centres rely on foreign radio for reliable news and ignore the Soviet mass media." Those results were never published.[11]

Naukovedenie done in the 1960s was largely quantitative, which draped it in a seemingly impenetrable cloak of scientific objectivity. Nalimov and his school closely followed in the footsteps of Derek Price. Their research concerned communication networks, publication and citation patterns, international exchange of scientific information. The All-Union Institute for Scientific and Technical Information (VINITI) collaborated with the Moscow University group and apparently provided it with institutional and other support. There is evidence that studies of scientific communication done during the last decade have helped policy making in the domain of information supply and retrieval.[12] One can even more positively state that VINITI often moulded the research of the Nalimov group, and regular contacts and substantial exchange of research personnel took place. Gradually VINITI developed its own research potential and engaged itself in a long-range study of the diffusion and consumption of scientific information.

Nalimov exercised considerable influence on the emergence of science study groups elsewhere in the USSR. His *Naukometria* popularized a quantitative approach to the study of research, and stimulated a relatively wide interest in the method. In Novosibirsk in particular, Shcherbakov and Grazhdannikov developed a research group at the Mining Institute. Their work extended the confines of the quantitative approach found in Nalimov's work, and they were the first in the USSR to correlate other science indices with publication and citation data. Economic, particularly econometric, and later sociological analyses of science were also made at Novosibirsk.

In making Siberia a propitious ground for *naukovedenie*, the example and activities of another group of enthusiasts was of the utmost importance, viz. that of Dobrov's group in Kiev. Rarely innovatory, methodologically or in terms of interpretation, Dobrov's group primarily replicated and expanded approaches found in the writings of Derek Price. More significantly, however, Dobrov, a

[11] S. M. Lipset and R. B. Dobson, "The Intellectual as Critic and Rebel . . . ," *Daedalus*, Summer 1972, p. 181.

[12] For a discussion of this and other inputs provided by quantitative *naukovedenie* see: Y. M. Rabkin, "Measuring Science in the U.S.S.R.: Uses and Expectations," *Survey*, Vol. 22, No. 2, 1976, pp. 69–80.

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former historian of mining, succeeded in presenting *naukovedenie* in the general framework of Soviet cybernetics, both in institutional and cognitive terms. This proved to be politically wise. Cybernetics, after a decade of banishment, had become singularly popular with government and scientists alike. Cybernetics was the hope of the new society, to be built on the premises of "Scientific Communism."[13] Not only were the Kiev scholars of science study (*naukovedy*) conveniently located at the Institute of Cybernetics of the Ukrainian Academy, but they, and Dobrov in particular, were instrumental in interpreting Derek Price and other quantitative students of science in terms of cybernetics and later in the dialectical immunity their field would enjoy. The prolific Kiev group has been actively productive since the mid-1960s. Their work mainly concerns science in the Ukraine, which is perhaps the best measured national science in today's world.

Naukovedy also compute statistics on scientific activities in the Soviet Union. Studies on the number of scientists in general and their distribution over particular fields and types of institutions, on output of publications, and other quantitative descriptions have produced a large amount of information. The magnitudes of science in the Soviet Union have been set into a comparative framework through juxtaposition with data in similar categories about scientists' activity in contemporary Western countries. In all these studies, much emphasis is laid upon the need to "rationalize the allocation of the scientific potential." An analysis of the territorial distribution of science in the Soviet Union and a classification of scientific centres into "regional," "complex," and "branch" types has been made at the Institute of History of Science and Technology,[14] whose role in the institutional development of the field has been steadily increasing since the late 1960s.

Institutionalization

Naukovedenie at the Institute of History of Science and Technology in Moscow has been quite diversified. The re-emergence of the very term *naukovedenie* and the first modern definition of the field is due to an article written by Mikulinskii and Rodny in 1965.[15] The article advocated the appropriateness of *naukovedenie* in an institution of history of science. The multidisciplinary character of the field prompted sociologists, historians of science, specialists in cybernetics and even in mining engineering, to argue for the location of *naukovedenie* research units within their respective institutions. Historians of science

[13] See, e.g., L. R. Graham, *Science and Philosophy in the Soviet Union*, New York: A. A. Knoff, 1972, Ch. IX.

[14] V. I. Duzhenkov, "Nauchnye tsentry v SSSR i ikh rol' v razvitii nauki," in D. M. Gvishiani (ed.), *Osnovnye printsipy i obshchie problemy upravleniya naukoi*, Moskva: Nauka, 1973, pp. 236–256.

[15] S. R. Mikulinskii and I. N. Rodny, op. cit.

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were largely successful. Mikulinskii, then deputy director of the Moscow Institute, brought about the establishment of a number of *naukovedenie* divisions within the institute, which he would eventually head. He secured important political support, particularly from the State Committee for Science and Technology. D. M. Gvishiani, one of the Committee's Vice-Chairmen, is the key figure linking *naukovedenie* and the makers of science policy. Formerly a sociologist specializing in the study of management, and probably the most eminent Soviet authority on American studies in management, he is also one of the most active proponents of the adaptation of Western ideas about management for the Soviet economy. His prominent position enables him to offer support and protection to those who draw from and cite American and other Western work on the administration of science.[16]

The active cultivation of *naukovedenie* in the Moscow Institute of History of Science and Technology is furthered by the close relationship between Gvishiani and Mikulinskii. They have jointly published a number of articles on *naukovedenie* and they have collaborated in the sponsorship of the *naukovedenie* series of publications.[17]

In addition to considerations of the improvements which are expected to flow from *naukovedenie* a demand for *naukovedenie* has come from the middle ranks of the organizations which administer science in the Soviet Union. They need it for advancement in their careers. A considerable proportion of these employees of the middle ranks are university graduates, mostly in the sciences. There are definite social and economic advantages in the possession of the more advanced degree of *kandidat*. *Kandidats* ordinarily obtain their degrees after several years of practical experience—both traditions and regulations allow persons well over the age of 30 to work for this degree. Middle rank party and government officials who seek a Ph.D. degree while they are employed in the administration of science naturally turn to *naukovedenie* for their dissertation. Many of them do their research for a doctorate in these fields. Whereas *kandidat* in engineering is a reasonable goal to aim for by a practising engineer who seeks an advanced degree, and *kandidat* in agricultural sciences by a manager

[16] See D. M. Gvishiani, "A Soviet View of Corporate Responsibility," *Business and Society Review*, 9 (Spring 1974), pp. 56–61; and D. M. Gvishiani, *Organizatsiya i upravlenie* (Moscow: Nauka, 1970). Gvishiani's freedom to import and propagandize American organization theories must have been enhanced by his family connection: he is a son-in-law of Premier Alexei Kosygin. For Gvishiani's ideas on science management in English see: D. M. Gvishiani, "Centralized Management of Science: Advantages and Problems," *Impact of Science on Society*, 22 (1–2), 1972, pp. 95–103. For a non-Soviet assessment of this phenomenon see: D. Schwartz, "Recent Soviet Adaptations of Systems Theory to Administrative Theory," *Journal of Comparative Administration*, 5 (2), 1973, pp. 233–263.

[17] *Naukovedenie: problemy i issledovanie*, Moskva: Nauka, 1968; D. M. Gvishiani, S. R. Mikulinskii, and M. G. Yaroshevsky, "Sotsial'nye i psikhologicheskie aspekty izutchenia deyatel'nosti uchyonogo," *Voprosy Filosifii*, 3 (1971), pp. 83–92; D. M. Gvishiani, S. R. Mikulinskii, "Nauchno-technicheskaya revolyutsia i sotsial'nyi progress," *Kommunist* 17 (1971), 19–31.

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of a farm, persons employed in administration of science cannot easily find a conventional discipline which would permit them to write a dissertation in their field. There was no possibility, at least up to the early 1970s, of obtaining an advanced degree in public administration, management, or even sociology as such; nor was *naukovedenie* recognized by the Central Degree Assessing Agency. It was, however, possible to define a dissertation topic in *naukovedenie* so that it would fall within the boundaries of philosophy, economics or history. History of science has also been one of the most common fields in which an administrator of science might become a *kandidat*. As a result, the Institute of History of Science and Technology in Moscow has become a centre of attraction for numerous administrators of science in that city who wish to work for an advanced degree. But even the desire for an advanced degree cannot account for the attraction which *naukovedenie* holds for Soviet officials. A considerable number of officials from the Academy of Sciences and the GKNT attend seminars and lectures on this subject at the Institute even though they are not working for advanced degrees.

Naukovedenie also attracts administrators because it gives them outlets for publication in their field in the series of books and monographs entitled *Naukovedenie: problemy issledovaniya*, published under the auspices of the Moscow Institute, and *Naukovedenie i informatika*, published by Dobrov's research team in Kiev. The annual and occasional conferences and symposia on *naukovedenie* also attract many administrators; the proportion of participants who are not attached to research institutes or universities has been steadily growing. Persons who were trained in the natural sciences, a characteristic of many Soviet administrators, but who are no longer engaged in scientific research, find *naukovedenie* congenial to both their intellectual and professional aspirations.

The Modification of Naukovedenie

Although social scientists were virtually absent among the early enthusiasts of *naukovedenie*, their role grew as the field's institutionalization increased. The Higher Party School in Moscow, the institutes and departments of philosophy in major Soviet centres, and individual " workers of the ideological front " gradually joined the *naukovedenie* movement and eventually contributed to its tangible modification. Works produced by the new adherents differ markedly from early science studies literature both in approach and in political overtones. They bear the clear imprint of works of most of the *naukovedy* whose contributions were mainly devoted to " the Modern Scientific and Technological Revolution." Ritualistic attacks began against Derek Price and other Western authors who had been previously held in almost religious awe by the early *naukovedy*. The first chord was touched by Mikulinskii at the International History of Science Congress

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in Moscow in 1971. In what now appears to be a wise political step, he initiated polemics with Price, and was the first to make a distinction between science studies in the USSR and those of the West. The thrust of Mikulinskii's arguments was directed against Price's assertion that in the Soviet Union as well as in the United States, the exponential growth of expenditures on science would cease within a few years. As we inferred elsewhere,[18] Mikulinskii could not believe that the USSR would continue to expand its science resources in the exponential fashion. He was aiming at quite a different target: to ostensibly draw a line between *naukovedenie* and the science studies pursued in the West. This would give *naukovedenie* solid political support at home and would destroy the often expressed enthusiasm about *naukovedenie* being the exceptional social science developed both by Soviet and Western scholars.

Mikulinskii's move was more significant in that it indicated that Price and the school of thought that he represented had already taken root in the Soviet scientific community. During the same Moscow Congress, Price was widely praised both by the scientific elite, such as Academician Kapitsa, and the rank and file Soviet participants. The cleavage between the attitudes of the natural scientists and the social scientists was also emphasized when Price addressed a mass audience of a Department of Chemistry but not of a Department of Philosophy. In contrast to the open meeting held with the chemists, the talk Price gave at the Institute of History of Science and Technology was restricted to a few pre-selected *naukovedy*.

Mikulinskii's efforts to "ideologize" his field could also have been a response to an uncompromisingly orthodox position taken by his colleagues in East Germany.[19] Their example could have given social scientists opposing *naukovedenie* a strong, virtually irrefutable argument that science studies were indeed not "beyond class approach." By picking up appropriate political rhetoric, Mikulinskii legitimized *naukovedenie* and secured for himself a position of its trustworthy champion. Mikulinskii was uniquely qualified for such a move. On the one hand, he had effectively encouraged serious *naukovedenie* research and was instrumental in acquiring support for it. On the other hand, he had proven himself a staunch "straight-liner" in the eyes of the political leadership of Soviet science.[20]

Although Mikulinskii's move in 1971 brought more old-guard doctrinaires into science studies, it also served to strengthen *naukovedenie* within the structure of the Academy of Sciences, more precisely in the Moscow Institute and at its Leningrad branch. No

[18] Y. M. Rabkin, "Origines et developpements . . .', op. cit.

[19] See, e.g., G. Kroeber and H. Steiner (eds.), *Science and Society*, Berlin, Institut für Wissenchaftstheorie und -Organisation, 1974.

[20] See, for example, a vitriolic political accusation of some timid anti-Lysenko critics entitled "We must unmask concepts inimical to Marxism" and printed soon after Stalin's death: I. A. Poliakov and S. R. Mikulinskii, "Razoblachat' vrazhdebnye marksizmu kontseptsii," *Voprosy Filosofii*, 2 (1953), pp. 230–234.

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doubt *naukovedenie* now became imbued with ritualistic political discourse. But at the same time, the scientometric and other empirical trends in the field were allowed to develop and expand. Among these were studies of scientific information flows, psychology of research activity, organization and management of science, logic of science and cautious empirical studies in sociology of science in the USSR. Thus *naukovedenie* has been legitimitized under two aegises: as a bona fide Marxist discipline duly critical of "bourgeois deviations" and as a technical quantitative field of expertise related to cybernetics.

Prospects

In the future, *naukovedenie* is likely to continue along the lines we have attempted to discern above. The current institutionalization of the field may eventually lead to the establishment of curricula in science studies, most probably on postgraduate level and within the Academy of Sciences. Empirical studies of Soviet science are to continue, although the civic fervour that characterized early *naukovedenie* writings seems to have died in the post-Stalin atmosphere. There are signs that a considerable part of empirical research conducted within the framework of *naukovedenie* may never result in open publication. Surveys, opinion polls, and other forms of social research are viewed as vehicles of covert feedback to science policy makers and research administrators rather than as instruments of change in the hands of scientists, as was the case in the 1960s. Descriptive studies of Soviet science would constitute the more original part of *naukovedenie* in the 1970s. As far as theoretical aspects of *naukovedenie* are concerned, little if anything can be expected. This pessimism is all the more justified because the modest theoretical advances made during recent years in the fields of science studies in the West are likely to be rejected by the conservative new recruits in *naukovedenie*.

The relative strength of Soviet science studies is likely to be linked with empirical survey-type research. Soviet scholars steadily acquire and at times develop the methodological skills of their Western counterparts, which tend to improve the quality of Soviet data. Moreover, it makes such results more compatible with those produced in the United States. This may open the way to transnational comparisons of research systems, which so far are extremely difficult to undertake.[21] Perhaps one of the main attractions of empirical *naukovedenie* lies in the monopoly which Soviet scholars enjoy over collection of data. Utilization of such data in joint US-Soviet projects may yield information significant in terms of both theoretical importance and better understanding of the Soviet research system.

[21] Attempts to arrive at meaningful transnational comparisons of science organization and policies were made mainly under auspices of the OECD and, to a lesser degree, UNESCO. See, e.g., C. Freeman and A. Young, *L'effort de recherche et de developpement en Europe occidentale, Amerique du Nord et Union Sovietique*, Paris: OECD, 1965; *The Research System*, Paris: OECD, 1972–1974 (3 vols.).

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Particularly promising may be research on the social status of scientists, their attitudes towards research and other professional roles, their perception of stimuli and obstacles in research, modes of decision-making in science administration at various levels as well as on work in the field of scientometrics. Given the close links between the *naukovedenie* community and the science policy-makers, the very orientations of empirical studies of Soviet science may point to bottlenecks in the development of science in the USSR as perceived by the country's science administrators. As we showed elsewhere, the beliefs of Soviet policy-makers in the area of science and technology make this group distinguishable among other Soviet elites.[22]

However difficult to undertake, empirical research on science policy-making on the national level could be attempted in the US and USSR. Such a joint survey, if designed and executed with the participation of both Soviet and American scholars at every stage, is likely to yield unique information on perceptions, attitudes, expectations, and socio-political institutional constraints operating in the scientific communities of the two nations.

There are two distinct groups of problems which may interfere with the eventual cooperation in the field of science policy studies: those specifically related to the field of enquiry and those characteristic of the Soviet system as such. While the latter are better known and hardly need elaboration here, the former, proper to *naukovedenie,* are worth discerning.

First, the institutionalization of Soviet science studies now under way may result in more centralized control of information available to American scholars. When *naukovedenie* was not centred in Moscow and was pursued on a more or less equal basis at a number of research centres around the country, access to research information and the possibilities of collecting primary data were greater and the authenticity of secondary data was easier to verify. However, the institutionalized *naukovedenie* may have some advantages as well. In particular, the close relationship between the Moscow Institute of History of Science and Technology and the State Committee for Science and Technology may reduce the amount of administrative hurdles in the way of Americans taking part in this cooperation. Relatively easy access to science policy-makers which Soviet, particularly Moscow-based, *naukovedy* enjoy may affect the working conditions of their American colleagues in the USSR.

The second disadvantage which may result from the current institutionalization of *naukovedenie* consists in the above mentioned influx of Soviet social scientists into the field. Increased ideological rhetoric may impede communication with American scholars. This would be particularly true when contacts are conducted in the United States. Politically more trustworthy, delegates of the "ideological

[22] Y. M. Rabkin, "Naukovedenie . . ." op. cit., p. 74.

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disciplines" are likely to be over-represented among Soviet *naukovedy* allowed to visit abroad. In terms of exchange visits to the US, Soviet research teams are likely to consist mainly of the *naukovedy* with orthodox professional backgrounds, and high-level science administrators. The bulk of professional historians and sociologists of science actually engaged in research may take part in cooperation exclusively within the USSR. This is conducive to an imbalance of benefits to be derived through visiting scholars by the two national communities, particularly as far as junior researchers are concerned.

Finally, Soviet *naukovedy* have considerably lower theoretical and methodological competence than their US counterparts. Even given their free participation in the exchange, the flow of information is likely to be mainly in the Soviet direction. This obvious disadvantage for American scholars can be partly remedied if not only respective US data, but also scholarly advice and expertise of the Americans are traded for relevant information collected by the Soviets and, more importantly, for opportunities for US scholars to conduct and/or participate in field research within the USSR.

In other words, if the American side does not find that the current stage of familiarization is sufficiently useful to justify further exchanges in this area, attempts can be made to exchange the higher expertise of the Americans for participation in the collection of empirical data within the USSR.

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American Science and Soviet Concerns *

Thane Gustafson

AMERICANS who visit Soviet research institutes or study science policy in the Soviet Union are struck by the vast differences between the two countries in the ways they approach the management of science. The tasks themselves are quite similar; in both countries they involve defining, supporting, evaluating, and applying the best possible scientific research. But each country approaches these tasks with its own traditions and its own spirit.

The arrangements which result are not necessarily equally effective. Americans familiar with Soviet science and science policy often feel that their Soviet colleagues are not getting as much high-quality science in return for their investment as they should, or as the Americans do. This is not due to any inferiority in the individual abilities of the Soviet scientists (visiting Americans rate them highly), but to the relative rigidity and inefficiency of their policies and organizational structures for science, which hinder the Soviets in responding to the rapid conceptual and methodological changes taking place in many disciplines.

The American system, though it has grown up largely without plan in response to the increase of federal support over the last 35 years, nevertheless appears to respond quickly to new opportunities in science and technology. Our organizational arrangements are highly flexible: the development and supply of scientific equipment, instrumentation, and computer facilities is handled by a multitude of small firms which can enter scientific markets rapidly and easily. Students and young researchers receive a broad scientific education, and move easily from one field to another, from universities to other sectors, and from pure research to applied research. The starting premise of the Americans appears to be that science is inherently unpredictable and uncertain, that detailed planning is stultifying, and therefore that the most effective policy for science is to build as much manoeuvrability as possible into the system. It is true that the arrangements which make the overall system flexible and responsive can be harsh for individual researchers and institutions. Scientific or technological failure often means elimination for fledgling firms or researchers. However, the rewards and intellectual opportunities offered to the successful appear to give scientists and entrepreneurs, especially the younger ones, enough incentive to take risks, and the system as a whole, in the view of most American observers, has been quite successful.

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The starting Soviet premise, in contrast, is that the broad development of science can be forecast and planned for. Duplication and competition are regarded as wasteful; the threat of unemployment or bankruptcy as a goad to productivity is considered destructive. The thrust of the Soviet science system is to reduce the burden of uncertainty to individuals and institutions—but at a cost, Americans feel, in lost efficiency and flexibility for Soviet science as a whole.

Do Soviet observers agree? There exists a large body of Soviet writing on the American science system. It would be of more than passing interest to know what Soviet observers see as the strong and weak points of American policy for R & D, and whether any part of it, in their view, is potentially useful to Soviet science. Such questions, in addition to their intrinsic interest for comparative public policy, have particular relevance for the future of joint US/USSR work on science policy, which has been one of the most productive programmes under the bilateral science agreement.

Two sorts of published Soviet works deal with American science policy. The smaller part of these publications comes from specialists on the " science of science " (*naukovedenie*), working in such institutions as the Institute of Cybernetics of the Ukrainian Academy of Sciences. Some of them are trained as mathematicians or systems analysts, and they are professionally committed to the " rationalization " of the R & D process. Their discussions of such topics as citation rates or forecasting methods often explicitly point to American experience as a model to follow.

The larger part is the work of specialists in American affairs, most of whom work in the Institute for the Study of the USA and Canada, the Institute for History of the Natural Sciences, and the Institute on the World Economy and International Relations (IMEMO)—all three belonging to the USSR Academy of Sciences. As a rule, they are trained not as natural scientists but as jurists, sociologists, or economists. The aims of this second body of writings are more complex than those of the first. We should bear in mind that Soviet writings of the latter type are partly intended for public consumption. Both the monthly journal and the monographs of the USA Institute are widely sold on Soviet news-stands and in bookshops. One of their purposes is to present the Soviet public with an officially approved picture of the United States. Nevertheless, these institutes are not mere propaganda mills. We know that many highly respected (and sometimes highly placed) specialists work in them, and that leading Soviet circles draw upon their advice. The literature itself is professional and competent. It is detailed, extensively referenced to American sources, and obviously carefuly researched.

What we do not know is whether it reflects the interests and concerns of Soviet scientists and science administrators. On a recent visit to Moscow, I asked Georgii Arbatov, director of the USA Institute, whether the work of his science policy specialists arises in response to the requests of

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science administrators for advice, and whether it is influenced by close consultation with them. Arbatov answered that his institute does answer occasional questions on US science policy from the Academy of Sciences and sometimes writes reports to the State Committee for Science and Technology. His tone conveyed, however, that these were the exception rather than the rule, and that most of the institute's studies are self-initiated. The purpose is not so much to advise on particulars as to present an informed analysis of general topics. One key point worth noting is that in their published work the Soviet Americanists never discuss the Soviet Union or compare American practices with Soviet ones (except of course at the most general ideological level), even though the general Soviet press is full of articles debating Soviet science policy.

To establish the usefulness of the Soviet literature, it is reasonable to lay down certain criteria of thoroughness and depth, and to ask whether it measures up to them. It should be noted that the Soviet members of the joint working group on science policy, many of whom are high-ranking figures in the USSR Academy of Sciences and in the State Committee on Science and Technology, do not appear to be aware of the Soviet literature on American science policy, and they remain curious enough about the subject to take the trouble to participate actively in a large joint project. The possibility comes to mind that the Soviet literature on American science policy is not addressing itself to (or answering satisfactorily) the questions that Soviet policy makers are most concerned about, and it is important to know why. This will be the main purpose of the discussion which follows.

I. Separating Science Policy from its Political Settings: What Parts Are Transferable?

Soviet descriptions of the American science system portray it as being shaped by two forces—one positive and one negative. On the negative side, it is a response to politics. The bourgeois state attempts to stabilize and rationalize the capitalist order, by regulating the monopoly corporations and by taking over tasks which they are unable or unwilling to perform themselves—such as basic research. Hence the enormous increase since the Second World War in the role of the federal government in supporting and managing science and technology.[1] However, in the Soviet explanation, the corporations have the power to subvert government policies and turn them to the purposes of big business.[2] Many of the characteristic practices of the American science system, such as that of reserving the bulk of the actual performance of the government-supported research for private institutions, are viewed in the Soviet sources as evidence that US science policy is subordinated to the interests of monopoly capital. Likewise, supporting science through a large number

[1] See for example Maslennikov, p. 183.
[2] Demin, 1974.

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of government agencies, a practice which is vaunted in American books as " pluralism of support," is seen instead as a reflection of the fierce competition which financial and industrial groups wage among themselves.[3] The great variety of organizational arrangements characteristic of US politics and the informality of our advisory mechanisms and administrative procedures only benefit the interests of influential business concerns,[4] All in all, concludes one writer, " under the conditions of capitalism the formation of a scientifically based, single, country-wide policy in any sphere of life is hardly to be expected," [5] and science policy is no exception.

At the same time, US science policy is also seen as a response to the needs and growth of science. The dominant trend in science today, as the Soviets see it, is the " industrialization of scientific production " (i.e. large multi-disciplinary teams, automation of data gathering and processing, increasing scale and complexity of research and development). According to Soviet theories, this trend towards " Big Science " causes corresponding changes in government science policy, towards increased centralization and rationalization through techniques like systems analysis, PPBS, cost-benefit studies, computerized information systems, advanced management systems (PERT, network analysis), etc.[6]

However, the Soviets' interpretative scheme leads them into an awkward paradox. " Advanced " methods of science management and evaluation have had mixed results in the United States (a point that Soviet observers are aware of), while many of the pluralistic, informal devices which are supposedly " political " adjustments (and hence " objectively " retrograde) turn out to be very useful for science. One Soviet book speaks of the Americans' constant readiness to experiment, not only in science, but also in politics and the economy, adding that this trait gives American science policy a high degree of flexibility and manoeuvrability.[7]

Nevertheless, the dual scheme used by Soviet analysts, if wielded imaginatively, could help do what the American science policy literature rarely does: that is, to distinguish conceptually between science policy and its socio-political setting. It should enable the Soviet observer, when he encounters a novel feature of American science policy, to identify its adaptive value for science (regardless of whether it fits the " objective tendencies of the scientific-technical revolution "), and then to determine whether it is potentially transferable to a different political and economic climate, or whether it is so clearly a product of American politics and culture that it would not survive a transplant. Such an analysis, if pursued systematically, would be very valuable—not least to Americans.

Unfortunately, the Soviet literature does not really meet this challenge. Its authors tend to stick to safe generalities. The features of the American science system which have the most interest in their eyes often turn

[3] Gromeka, p. 111.
[4] Sheinin, p. 163.
[5] Maslennikov, p. 184.
[6] For example, see Frolova.
[7] Sheinin, pp. 164–5.

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out to be already a part of approved Soviet practice: for example, the growing use of Soviet universities as centres for graduate training and advanced fundamental research,[8] or the use of contracts to facilitate the application of research findings to technology,[9] or the fashion for systems methods.[10] Because of their caution, Soviet observers tend to remain at the surface of the most interesting issues, passing along the views of American writers, but venturing an opinion themselves only when it falls squarely within their overall interpretative scheme.[11]

To illustrate this point, let us take one of the most distinctive differences between the Soviet and American science systems. In financing research, the Americans rely primarily on the so-called " project system," which supports individual researchers (by means of grants and contracts) rather than institutions.[12] The Soviet system is based instead on block funding of large institutes, whose directors and heads of laboratories have great power over the choice of projects to be supported.

In the project system difficult questions of political power and of scientific effectiveness are intertwined. Let us take first the matter of effectiveness, focusing particularly on project grants, which in the United States are the principal means of support for fundamental research. Their advantage, in the Americans' eyes, is that they select the most promising research topics through a nationwide competition instead of a local one. This ensures, at least in principle, a higher level of scientific merit and flexibility than institutional funding can, since the reviewers of each proposal are nationally known specialists in the same precise field as the applicant. They can make their decisions without being affected by the internal politics of institute or university departments. Soviet observers recognize this advantage. Commenting on the project grant system, which he had seen at work in the United States, the deputy director of a Soviet research institute contrasted it with his own system:

> I cannot recall a single instance in which the funds allocated to us by the Academy of Sciences ever depended on what was written in a proposal. Even within the institute itself, the allocation of resources is more apt to depend on the number of personnel in a laboratory than on the productivity of the research conducted there.[13]

[8] The role of American universities as performers of federally supported basic research is discussed in Lebedeva, pp. 77–102.

[9] Extensive discussion of the use of contracts in American R & D can be found in Ivanov, pp. 329–51.

[10] American use of systems methods in military R & D is reviewed by Gromeka, pp. 189–91.

[11] See for example Gromeka, p. 111.

[12] See for example Lebedeva, p. 85, or Golovanov, pp. 48–49. In recent years a growing share of applied research in the Soviet Union is being funded through " economic contracts " (*khozdogovor*) between institutes and industry. However, direct institutional support remains the basic method.

[13] Simonov, 1968, p. 71. At the time this article was written, P. Simonov was Deputy Director of the Institute of the Activity of Higher Nervous Systems and Neuro-physiology of the USSR.

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In other words, the project grant system transfers to the national policy-making level the responsibility for extra-scientific considerations such as stability of employment, maintenance of facilities, or encouragement of young or minority group researchers. This in turn makes possible, again in principle, a more finely tuned management of the quality and progress of each field, and a more rapid response to new ideas, than can be achieved under a system of institutional funding.

Soviet sources also comment that the project system makes it possible for scientist-administrators in Washington to influence the direction of research, because support can be adjusted at the "margins" of each field, when the researcher applies for renewal. Sheinin notes that the unsatisfactory researcher will "lose face" and will be denied further awards.[14] Soviet observers agree that this system makes researchers "more active." In contrast, explains one Soviet researcher, under the Soviet system of funding by institute,

> . . . the excessive generosity with which we are funded sometimes creates conditions which support idle exercises for years, under the umbrella of "unlimited freedom of inquiry." The champions of this freedom passionately exclaim, "Who can deny the possibility that my thesis, which seems unpromising today, may cause a revolution in scientific theory tomorrow!" Then examples are cited from the schoolchild's history of great scientific discoveries. . . .[15]

Soviet writers point out that the National Science Foundation has used the leverage given to it by the project grant system to support new trends and ideas, and to encourage intensive work in fields which the Foundation feels are ripe for major advances.[16]

On the other hand, the Soviet literature is aware of the uncertainties that the project grant system creates for the researcher: ". . . we don't have to worry constantly about whether or not we will be able to continue experiments that have begun to seem unpromising or inconsequential to the funding body . . ."[17] A related problem, in the Soviets' view, is the paperwork and delay produced under the project grant system. Soviet visitors to American laboratories are astonished at the amount of written justification that must be supplied to Washington. One book quotes a Princeton scientist on the "endless obstacle course and bureaucratic process" associated with applications for grants.[18] It may seem ironic to hear Russians criticising other countries for their red tape, but American visitors to the more prestigious Soviet institutes agree that their Soviet colleagues do not seem to have to submit as elaborate written justifications as does, say, the American director of a national centre.

The project system can also be analysed as a response to a political problem. Its origins as an administrative device lie in philanthropic

[14] Sheinin, p. 144.
[15] Simonov, p. 71.
[16] Lebedeva and Nedotko, pp. 118–19.
[17] Simonov, p. 71.
[18] Gromeka, 1974, p. 168.

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foundations [19]; and it was adopted by government agencies in an effort to reassure university scientists that government support of science would not mean government dictation. The crucial issue here is control over directions of research. Feelings run high among American scientists and administrators over whether it is better to set research priorities " from the bottom up " by relying primarily on the opinions of researchers, or " from the top down," by relying on those of scientist-administrators. As it turns out, the project system can be turned to serve either viewpoint, depending on the field and the agency involved. The implications of this point are one of the most hotly debated topics in American science policy.

Unfortunately, Soviet observers do not venture very far into it, or into the connections between political power and scientific effectiveness. Take for example Soviet references to " proposal pressure " (that is, the variable " pressure " generated by the flow of grant proposals from each field), which is used by some science-supporting agencies as a guide to priority setting.[20] Now, the " scientific " rationale for using proposal pressure, as one Soviet writer notes, is that it reflects researchers' perceptions of the intellectual opportunities available to them, and hence it can be a valuable indicator of the needs of various disciplines. But at the same time, an exclusive reliance on proposal pressure means abandoning control over priority-setting to the scientist in the field. In recent years, scientist-administrators in Washington have tended to assert their own authority and to rely less on proposal pressure. This may be the most important single trend in American science policy today. But it is not dealt with to any great extent by Soviet observers.

Similarly, one of the most difficult issues in the project mode of support is the proper role of " peer reviewers ": non-government researchers who come to Washington to judge proposals and give advice. Soviet sources recognize the significance of the peer review committees,[21] which under the name " expert commissions " (*ekspertnye komissii*) are also widespread in the Soviet Union. However, the Soviet literature gives little space to an important countervailing trend, the growing role of professional administrators, such as the programme directors of NSF, and their often competitive relations with peer review committees. One Soviet observer appears to believe that the influence of outside scientists is growing relative to that of professional science administrators.[22] But most American scientists believe the opposite.[23]

[19] The role of the foundations is well discussed in Sheinin, pp. 122–3. In contrast, for a specimen of polemical " know-nothingism " at its worst, see Bidnvi.

[20] Sheinin, p. 149.

[21] E. G. Lebedeva, p. 86.

[22] Sheinin, p. 154.

[23] The reason for this difference of opinion may be that the Soviet writers focus on the " two stage " form of peer review (widespread in NIH), which does give outside researchers great influence. However, there also exist " one-stage " and " mail review " forms, which give the administrator far greater power and these are not discussed.

See for example Gromeka (1974, pp. 167–8). He appears to believe that there is a

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Perhaps the most controversial of all questions surrounding the peer review system is whether it is representative or fully honest. One Soviet source adopts without comment the view of some American critics that a "lobby" of the privileged universities (one of the signs of which is over-representation on peer review committees) accounts for their dominant share of federal support.[24] Another, while acknowledging that the "privileged" universities have the highest concentration of leading scientists, asserts that this is due to the abundant flow of funds produced by the lobby.[25] This is too easy. The difficult questions linking scientific quality and science policies are passed over too lightly. A thorough analysis would attempt to discuss whether the present distribution of funds is out of line with the scientific merit of the work supported (including the question of whether the latter may be measured by any convenient means, such as citation rates) and whether another criterion, such as equality of support among geographical regions, should apply instead.[26] Similar debates are going on even now in the Soviet Union: one Soviet scientist, in a widely noted article in *Literaturnaya gazeta*, has proposed supplementing traditional systems of reviewing in the Soviet Academy of Sciences with the use of citation rates.[27] The participants in this debate would surely benefit from an awareness of the early American enthusiasm for citation rates and their subsequent disenchantment, thus saving themselves time and trouble in the process.

II. Weighing the Pros and Cons of Potentially Transferable Arrangements

In this section we turn to a different question: having isolated valuable and potentially transferable features of another country's science system, the analyst must then identify the trade-offs associated with each. Soviet observers, it is clear, find many features of interest in the American system: project grant funding, small firms for rapid innovation, broad

"three-stage" peer review, in which university administrators select the best proposals for submission to Washington. In an interview in Moscow, the Deputy Chief of the Science-Organization Section of the USSR Academy of Sciences, Doctor Nemchinov, seemed to have the same impression from a visit to the United States. In contrast, Sheinin correctly notes that the project-grant system weakens university administrators.

[24] Gromeka, 1974, p. 173, and Sheinin, pp. 156–7.

[25] Sheinin, p. 160.

[26] Thane Gustafson, "The Controversy over Peer Review," *Science*, Dec. 12, 1975.

[27] A. Kitaigorodskii. The use of citation rates in the Soviet Union has been confined until recently to the compilation of bibliographies as an aid to researchers. Soviet work on citation rates for policy uses has been hampered by the lack of an indexing system based on Soviet sources alone. Soviet specialists have been obliged to rely on the ISI Science Citation Index, which provides very incomplete coverage of the Soviet literature. See T. V. Sorokina, E. D. Grazhdannikov, "Tematicheskii bibliograficheskii poisk s pomoshch'iu ukazatelia tsitirovannoi literatury," *Naukovedenie i informatika*, vypusk 13 (1975), pp. 64–68. Soviet specialists are now working on the development of a citation index of their own, based on the second generation Minsk-22 computer. See D. M. Mekhtiev, A. M. Babaev, A. M. Rustamov, Y. M. Karpachev, "Avtomatizirovannaya podgotovka ukazatelya tsitirovannoi literatury i razrabotka informatsionno-poiskovoi sistemy na ego baze," *Nauchnotekhnicheskaya Informatsiya*, seriya 1. Organizatsiya i metodika informatsionnoi raboty. (Moscow, VINITI), 10–1974, pp. 22–28.

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scientific education, mobility of personnel, computerized information systems tailored to the needs of the users, etc. But each of these features is achieved at a price: to gain mobility and flexibility of research personnel, one must tolerate higher unemployment and turnover. The project system, because it creates the necessity of competing for support at frequent intervals, wastes time and builds anxiety. Concentrating research and graduate education in universities distracts the faculty from undergraduate education. The multiple approaches to a scientific problem made possible by pluralism of support carry with them increased duplication, dispersion of effort, and possibly waste of resources.

What these pros and cons amount to, when taken together, is a series of alternatives between flexibility and uncertainty. To judge from the topics to which they give the greatest attention. Soviet science policy analysts are most interested in features which will provide them with added flexibility. But at the same time they must confront the fundamental question of whether gains in flexibility are worth the costs in increased uncertainty, and if so, who shall bear the burden of it.

Once again, such an analysis, if pursued systematically (and if combined with a discussion of the Soviet values and traditions that these features would have to be adapted to) would be an extraordinarily valuable exercise. Unfortunately, in this case also the Soviet literature does not venture very deeply into analysis. Though they are clearly aware of the problem of side effects, they seem to be constantly tempted to ascribe them to the American political system, rather than to recognize them as alternatives inherent in the task of science management itself. Thus they ascribe the high death-rate of small innovating companies, whose contributions to technology they recognize, to the disorder of the private sector, "with its crises and anarchy, and unrestrainable competitive struggle among corporations for profits and superprofits by any means and methods."[28] Moreover, there are odd gaps in the Soviet coverage. American methods for the financing and procurement of scientific supplies and instrumentation, for example, are scarcely mentioned, although we know that supply is a serious and controversial problem in Soviet science policy.

Nevertheless, what discussion there exists is impressive in its command of facts and its general accuracy. The strongest analyses deal with the planning of resources for scientific manpower and education. The reader will be able to judge for himself from the next two sections.

1. Training and Management of Scientific and Engineering Manpower

The main problem in designing a manpower policy in any science policy system is to fit uncertain supply to fluctuating demand. Since it takes a long time to train scientists, one must either try to foresee future demand or to make the supply more flexible. The Soviet response, by

[28] Gromeka, pp. 43 and 56.

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and large, has been directed towards the former, the American towards the latter. American universities, unlike those of the Soviet Union, are not responsible for the placement or support of their graduates; US enterprises and administrations do not supply VUZy with statements of their future manpower needs; there is no system for assigning new graduates to their first jobs. Such devices are all the more necessary in the Soviet Union because of the generally high degree of specialization of the graduates, even at the first degree level. Even so, there are regular complaints in the Soviet press that many graduates end up in jobs which do not match their training.

This may account for the great interest shown by Soviet observers in the flexible arrangements devised in the United States: broad theoretical education, mid-career retraining, up-or-out promotion systems, etc. Soviet sources mention that the United States trains an abundance of technicians in advanced specialities (one article comments on the availability in neuro-physiological research of electrode specialists, mechanics, and laboratory technicians skilled in radio engineering).[29] Similarly, the Americans get high marks for using the universities as the main instrument for combining fundamental research with graduate education. This arrangement has the important result of making available to undergraduates the up-to-date skills and knowledge of active researchers—a proven guarantee against outmoded theories and instruction by rote. Current reforms in Soviet scientific education are designed to give students the same kind of training. A recent Soviet book gives a lengthy account of debates surrounding scientific education in America, noting complaints by corporations that students are receiving too much theory, that the undergraduates leave the universities with a background that is too broad, and the graduate students with one that is too narrow. The book also notes the counter-arguments of the universities and gives an account of various work-study and on-the-job training arrangements which attempt to integrate theoretical knowledge and practical skills. On balance, the Soviet authors favour a broadening of background, in line with current policy in the Soviet Union.[30] Similarly, though, they note a tendency in the United States to pursue the "fashionable" specialities of the moment and to neglect the traditional ones.[31] Soviet observers praise the capacity of the universities to adapt scientific curricula quickly to new techniques and discoveries. They also praise corporations for their programmes to retrain scientific personnel in mid-career, and they note the widespread use of educational television. They make the interesting comment that American corporations are generally disappointed with part-time retraining, a point of some importance in view of the fact that part-time programmes are the rule in Soviet industry.

On American policies for the management and remuneration of scien-

[29] Simonov, p. 72.
[30] Ivanov, ed., p. 153 ff.
[31] Ibid.

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tific personnel, Soviet observers take the position that, although their essence is exploitative, they have a certain "positive interest." Research frameworks are highly mobile,[32] partly because of the use of "up-or-out" systems of promotion in universities.[33] This permits corporations and universities to respond to new research problems through the rapid formation of inter-disciplinary teams, which can be reorganized as the situation requires, with the addition or removal of personnel as the project proceeds.[34] Hence US corporations are able to meet tight deadlines even during periods of heavy load. Simonov points out that the Soviets have an equivalent to this in the form of the so-called "creative group," but he hints that the more common form of organization in the Soviet Union is the narrowly specialized laboratory.[35] Soviet observers also point to the creative use of salary and promotion policies in the United States: whereas the only way to raise the salary of a Soviet scientist is to promote him to a position which includes burdensome administrative duties, American corporations such as Westinghouse use a dual-ladder system, which makes it possible to promote talented and productive scientists while keeping them in the laboratory.[36] A recent source notes that corporations have devised rating systems which set scientists' salaries on the basis of a blend of seniority and achievement. The merits and drawbacks of such systems as well as the use of varied perquisites as an effective alternative to direct monetary rewards, are discussed at great length.[37] One of their special virtues is that they make it possible to reward the younger scientist, a point of special concern in the Soviet Union.

On the negative side, the Soviet literature notes the threat of unemployment and the lack of accountability on the part of universities for the placement of their graduates.

2. Structure and Uses of Scientific Information Systems

The United States and the Soviet Union face similar problems in managing a growing flood of scientific information. The essential requirement of information systems is to provide the working scientist, engineer, executive, or policy-maker with information that is up to date, comprehensive, significant, easily accessible, and most important, tailored to his real needs. In the last 10 years both countries have built up elaborate and expensive systems for scientific and technological information,[38] but are far from satisfied with the results.

Soviet discussions of American information systems focus on three aspects: automation, centralization, and public availability. They note

[32] Sheinin, p. 135; Golovanov, p. 49.
[33] Khazina, p. 68.
[34] Maslennikov, 1971, p. 168; Simonov, p. 73, etc.
[35] Simonov, p. 73.
[36] Khazina, p. 67. Simonov also comments on this point.
[37] Ivanov, ed., pp. 164–74.
[38] Golovanov, 1974, pp. 32–61.

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American achievements in using computers [39] (especially remote terminals with visual displays), photo-offset, and other rapid means of reproduction and processing. At the same time they observe that the United States went too far too fast during the 1960s in pushing the use of computers for information systems, often producing more information than could be used, especially at upper management levels. One source mentions that corporations at first had a tendency to acquire computerized information systems for the sake of novelty and prestige, a failing for which Soviet ministries are also criticized in the Soviet press.[40]

Thus, according to Soviet observers, Americans have learned the hard way that scientific information must be adapted to the individual user. However, though the Soviet literature recognizes the necessity of this, most of their discussions focus instead on the organization of *supply* and give little attention to the problems of organizing its effective *use*.[41] In particular, they make no mention of the large American literature on the importance of face to face contacts and oral communication in effective information transfer.

A case in point is the Soviet discussion of the technology transfer programme of NASA. It is cited by one Soviet source as the outstanding example of a modern scientific information programme,[42] but what is not mentioned is that it was largely a failure.[43] Indeed, the NASA experience demonstrates particularly vividly that the most effective mechanisms of transfer are direct contacts among people and mobility of employment by technologists and applied scientists. Equally important methods of technology transfer are new, technologically-based spin-off firms, created by individual entrepreneurs.

Soviet observers note a trend towards centralization and governmentalization of scientific and technological information systems,[44] but appear undecided whether these are positive developments or not. On the one hand, centralization is good, because it makes possible efficient gathering and dissemination of information. On the other hand, efficient *use* of information appears to require decentralization. A detailed discussion of this dilemma would be most useful for both Soviet and American science policy, but the published Soviet sources do not undertake it.

Finally, it is of interest to note the views of Soviet observers on the *purposes* of information systems. Two which are mentioned are: to promote rapid technology transfer, and to curtail duplication of research.

[39] Lebedev, 1973, p. 103.

[40] Ivanov, ed., p. 198 ff.

[41] For American discussions of this point, see for example William J. Price and Lawrence W. Bass, "Scientific Research and the Innovative Process," *Science* 164: p. 802 (May 16, 1969), and D. G. Marquis and T. J. Allen, *American Psychologist* 21: p. 1052 (1966).

[42] Gromeka, p. 382.

[43] Samuel I. Doctors, *The NASA Technology Transfer Program: Evaluation of the Dissemination System* (New York: Praeger, 1971).

[44] Lebedev, p. 93 and p. 99. However, Lebedev points out that there is no single statewide system like the Soviet VINITI network. Rather there are several types of information services which are quite loosely connected to one another.

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For most Soviet observers, duplication is a bad thing. According to one source, it absorbs 10 per cent of the R & D expenditure of the private sector. The possibility that a certain amount of duplication might have value, both as a means of continuous verification of the validity of the work being done and as a stimulus to further effort, is not mentioned.

Taken as a whole, the Soviet work cannot be accused of being imbalanced. Its fault is that it is not analytical. It does not establish whether the virtues it praises and the faults it criticizes are somehow inherently connected to one another. Until such an effort is made, such elaborate descriptions will not be very useful to a policy-maker.

3. Policies for Supplying Instrumentation, Equipment and Scientific Supplies

Surprisingly, Soviet sources give little attention to US problems of supplying instrumentation, equipment, materials and specialized services (such as machine shops, glass blowing, and computer services). This is known to be one of the most serious problems of Soviet scientists, even in high priority laboratories. Several aspects of the American experience could be useful to Soviet scientists. Why, then, does this issue receive so little attention?

One possible explanation is simply that Soviet observers are misled by the American sources. Since material supply is not generally perceived as a problem in the United States, it receives little attention in print. The one exception occurs when federal *funding* for computers or laboratories drops off and scientists voice their alarm through publications of the National Academy of Sciences and similar channels.[45]

The apparent omission of any detailed discussion of logistics is especially noteworthy when one remembers that one of the dominant features of the scientific technological revolution is supposed to be the " industrialization " of scientific research.

A major and unique exception to the general silence on this question is an article by P. Simonov, Deputy Director of the Institute on the Activity of Higher Nervous Systems and Neuro-physiology in the USSR. This is an especially interesting article because it is one of the few to be written by a scientist, moreover by one who has actually done research in the United States, and it is the only article available to make explicit comparisons between the US and USSR. Simonov's article, written in the late sixties, stated bluntly that the Americans' superiority in modern, standardized equipment gave them the edge in neuro-physiological research. Computers, he reported, were used to programme and monitor

[45] Maslennikov, 1971, p. 151. This shortage was explained by the fact that the bulk of government funding for universities and colleges was earmarked for defence-related projects. Since that time, however, a decade of debate has produced vastly more generous provisions for overheads in government grants and contracts, and during the 1960s American universities received ample federal support for the purchase of instrumentation and the construction of laboratories.

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experiments, process data instantaneously and display it in visual form.[46] The situation in the USSR has improved somewhat since then, but not fundamentally.

Many Soviet sources do comment on American arrangements for making efficient *use* of equipment and facilities. An article on NSF gives high marks to the Foundation's efforts to promote user-sharing arrangements,[47] and an analysis of science parks in the United States notes that they provide centralized technical support, such as computer services, machine shops, glass blowers, etc.[48] Thus the impression left in the mind of the Soviet reader is that the Americans must presumably face the same difficulties with material supply as their Soviet colleagues, since they deal with them through much the same arrangements as those which are advocated in the Soviet press.

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Scientists in the USA and the USSR*

Linda L. Lubrano and John K. Berg

IT could be said that science transcends national boundaries and that despite the differences in social systems, scientists have similar professional roles defined by the substantive similarities in the nature of their work. Theories of social change postulate that modern, complex societies provide comparable environments for the emergence of specialist elites. Scientists are specialists with knowledge that is particularly useful during periods of advanced technological development and this tends to give them an elitist orientation. From the above premises one might expect scientific elites in the United States and the Soviet Union to have similar career experiences. However, scientists perform their professional roles within different institutional contexts. The social structures and traditions of their respective societies provide opportunities and impose constraints that may result in substantial differences in a scientist's career pattern.

In both the Soviet Union and the USA scientists work as researchers, teachers, and administrators of science. They are recognized as specialists by virtue of their particular expertise and scientific competence. Evaluations by their professional peers contribute to a sense of self-regulation and professional autonomy. Judgments of scientific performance result in distinctions within the scientific community whereby some scientists obtain greater prestige and influence than their colleagues. Meanwhile, the effects of science and technology are felt throughout society. The need for technical expertise increases as societies become more developed; those with specialized knowledge generally acquire a relatively high social status.[1] The emergence of scientific elites in the USA

* This article is part of a study entitled "A Comparative Analysis of the Career Patterns of Soviet and American Scientists." The entire project focuses on natural scientists in the USSR Academy of Sciences and the US National Academy of Sciences from 1920–70. Based on biographical data, it compares Soviet and American scientists as specialist elites performing comparable professional roles in two complex societies. The study was sponsored by a grant from the Division of Social Sciences in the National Science Foundation. © Linda Lubrano 1978.

Since this is the first presentation of material from our data files, considerable attention has been given to a description of the scientists' background characteristics. In future we intend to place greater emphasis on the theoretical aspects of our analysis. There are inherent limitations to the use of biographical data, which tend to stress formal role distributions and career structures. The authors hope, therefore, that readers will view the findings in this article in conjunction with other sources of information on science policies, informal associations, and the behaviour of scientists in social institutions.

[1] Of course, this is not universally nor consistently true. The social status of scientists is affected by political and economic pressures at different stages of each country's history.

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and the USSR is therefore a product of the differentiation within the scientific establishment and a reflection of the growing complexity of modern societies.

The processes of differentiation in science and the modernization of society occur at different paces and acquire different institutional forms in each country. Contrasting social institutions help to shape the ways in which professional roles are interpreted and performed. Cultural and historical factors further contribute to the differences between scientists in the United States and the Soviet Union. It is expected that the opportunities and constraints of their respective environments will be reflected in the background characteristics and career mobility of the scientists themselves.

In order to compare the similarities and differences in the career patterns of scientific elites, we selected members of the US National Academy of Sciences (NAS) and the USSR Academy of Sciences (AN) for our study. Each Academy provides an institutionalized mechanism for awarding high social status and prestige to a small portion of the scholarly community. Membership in these Academies represents formal recognition of scientific distinction and eminence. Judgments of scientific competence are made by current Academy members, i.e. scientists who already hold influential positions within the scientific establishment. Both Academies are vulnerable to inbreeding and personal pressures during the selection process. Nonetheless, Academy members are accepted as scientific elites by their professional colleagues at home and abroad. Furthermore, they are recognized by politicians and other non-scientists as prominent specialists with knowledge useful to scientific research and development.[2]

Our primary concern is with the careers of scientists rather than with the institutional dynamics of each Academy. There are, in fact, some important differences between the two organizations. Both Academies claim a commitment to the development of science, but they fulfil this commitment in different ways. The NAS functions mainly as an (independent) advisor to the US government, while the AN functions as a research establishment. Consequently, they have different internal structures, operational procedures, and relationships with their respective political institutions. While some of the NAS members serve on its Governing Council and numerous committees, their primary affiliations are with universities and other organizations. By contrast, members of the AN are its employees, with responsibilities within the Academy that range from research and teaching to the formulation and implementation of science policies.

This paper tries to answer two sets of questions regarding the careers of American and Soviet scientific elites. First, do the scientists who acquired elite status through the NAS and the AN have similar

[2] There are alternative ways to define scientific elites. The use of citation patterns, for example, and other indicators of elite status may indeed result in different samples.

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background characteristics? Secondly, is the institutional and regional mobility of scientists in each country different, perhaps as a reflection of their respective traditions and social structures? Before proceeding with our comparisons of Academy scientists, we shall briefly describe our frame of reference.

OUR study was restricted to natural scientists in the fields of physics, chemistry, and biology. We collected and processed the data separately for those who were members of the AN or NAS in 1970 and those who were in each academy between 1920–69, but who died by 1970. The latter are referred to as the "deceased members." This enabled us to make cross-national comparisons for 1970 separately from the longitudinal study of Academy members between 1920–70. We wanted to know whether the 1970 samples were "typical" of trends among earlier members and, if not, how they differed.

American scientists were drawn from the 1970 NAS membership list and the NAS cumulative listing of deceased members. Each name was checked in the *American Men (and Women) of Science*[3] for the person's professional field. Similarly, the Soviet samples were drawn from the 1970 cumulative AN membership list and compared with our data file for professional fields.[4] Although we refer to four "samples," our data actually included almost the entire population of natural scientists in the Academies from 1920–70.

The number of scientists in the 1970 American sample was 470. This represented approximately 0·19 per cent. of the total number of physicists, chemists, and biologists employed in the United States in 1970.[5] The number of scientists in the 1970 Soviet sample was 261. This represented slightly more than 0·15 per cent. of the total number of physicists, chemists, and biologists employed in the USSR in 1970.[6] Although there may be some discrepancies in the comparability of the national statistics, the samples were similar in magnitude and represented a very small proportion of their respective scientific communities. The American deceased members were 175, bringing the

[3] *National Academy of Sciences of the United States of America: Membership* (1 July 1970); "Deceased Members of the National Academy of Sciences, March 1863 through June 1970," *Annual Report of the National Academy of Sciences*, Fiscal Year 1969–70 (Washington, D.C., 1973), pp. 247–256; *American Men (and Women) of Science* (3rd–12th editions; New York: Jaques Cattell Press, 1921–73).

[4] Paul K. Urban and Andrew I. Lebed, *Soviet Science: 1917–1970*, Part I (New Jersey: Scarecrow Press, Inc., 1971), pp. 196–265 and 316–318. Professional fields were recorded on intermediate data cards from *Prominent Personalities in the USSR* and other sources cited in footnotes 8 and 9.

[5] The total number of scientists employed in these fields was 253,100. The US bureau of the Census, *Statistical Abstract of the United States: 1973* (Washington, D.C.: US Government Printing Office, 1973), p. 527.

[6] The Soviet samples include both full and corresponding members of the AN (This distinction was coded and used in another part of the project.) The 1970 sample is slightly more than 0·15 per cent. because the base of 178,429 includes mathematicians. Tsentral'noe statisticheskoe upravlenie pri Sovete Ministrov SSSR, *Narodnoe khozyaistvo SSSR v 1970* (Moskva: Izdatel'stvo "Statistika," 1971), p. 657.

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total number of NAS members in physics, chemistry, and biology between 1920–70 to 645. The Soviet deceased members were 136, resulting in 397 natural scientists in the AN between 1920–70.

Sources included membership lists and biographical directories. The former were a matter of public record and were published by the Academies in both countries. The key directories for the American biographical data were *The American Men (and Women) of Science* and *Who's Who in America.*[7] These publications used questionnaires to obtain their biographical information directly from the individuals concerned.

More than 18 directories were used for the collection and verification of data on Soviet scientists, in addition to Soviet encyclopedias and professional journals. Almost half of the biographical directories were compiled by the Institute for the Study of the USSR in Munich.[8] The 1968 volume (*Prominent Personalities in the USSR*) included corrections and supplementary information submitted by some of the scientists themselves. Our research into other sources contributed to the expansion of the data base and the reduction of errors.[9] Each source was indicated on the intermediate data cards and used as a guide in coding.

The following information was coded for each scientist:

Identification number
Sex
Year of birth

[7] *American Men (and Women) of Science*, op. cit.; *Who's Who in America* (11th-37th editions, Chicago: Marquis Who's Who, Inc., 1920–73). Other reference works such as the *Dun and Bradstreet Million Dollar Directory* (New York: Dun and Bradstreet, Inc., 1975 and 1976), were consulted for coding when necessary.

[8] Edward L. Crowley, *et al.* (eds.), *Portraits of Prominent USSR Personalities*, Vols. I–IV (New Jersey: Scarecrow Press, Inc., 1968–71); Edward L. Crowley, *et al.* (eds.), *Prominent Personalities in the USSR* (New Jersey: Scarecrow Press, Inc., 1968); Andrei Lebed (ed.), *Key Officials of the Government of the USSR and Union Republics*, series II, no. 81 (Munich: Institute for the Study of the USSR, 1962); Andrei Lebed (ed.), *Prominent Personnel of the Academies of Science of the USSR and Union Republics* (Munich: Institute for the Study of the USSR, 1963); Andrei Lebed, *et al.* (eds.), *Who's Who in the USSR: 1965–66* (New York: Scarecrow Press, Inc., 1966); Heinrich E. Schulz, *et al.* (eds.), *Who's Who in the USSR: 1961–62* (New York: Scarecrow Press, Inc., 1962); Paul K. Urban, *Soviet Science*, op. cit.

[9] Battelle Memorial Institute, *Directory of Selected Scientific Institutions in the USSR* (Columbus: Charles E. Merrill Books, Inc., 1963); Biographic Reference Aid, *A Guide to the Academies* (May 1961); *Ezhegodnik bol'shoi sovetskoi entsiklopedii* (Moskva, 1965–71); Intelligence Research Aid, *Directory of Soviet Research and Educational Organizations* (Dec. 1964); *Soviet Political Leaders: Personnel in the Communist Party, Government, and Mass Organizations of the USSR and Fifteen Soviet Republics* (July 1957); Ina Telberg, *et al.* (eds.), *Who's Who in Soviet Science and Technology* (2nd ed.; New York: Telberg Book Corporation, 1964); A. V. Topchiev (ed.), *Nauchnye kadry v SSSR* (Moskva: Izdatel'stvo Akademii nauk SSSR, 1959); John Turkevich (ed.), *Soviet Men of Science* (Princeton: D. Van Nostrand Co. Inc., 1963); US Library of Congress, *Scientific Institutes and Laboratories in Moscow* (Washington, D.C.: Aerospace Information Division, 1963); US Library of Congress, *USSR Scientific Research Institutes* (Washington, D.C.: Aerospace Information Division, 1962); *Vestnik Akademiya nauk SSSR* (Moskva, 1967–71), *World of Learning: 1966–73* (London: Europa Publications Ltd., 1966–72); A. A. Zvorykin (ed.), *Biograficheskii slovar' deyatelei estestvoznaniya i tekhniki* (Moskva, 1958).

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Year of death (if applicable)
Place of birth [10]
Education: type of degree,[11] type and location of institution where educated,[12] major fields, years of graduation
Professional field
Research positions: type of position, type and location of institution, years in which the position was held
Teaching positions: type of position, type and location of institution, years in which the position was held
Administrative positions: type of position and institution, location of institution, years in which the position was held
Academy memberships (Americans: date of election to NAS; Soviets: dates of election to AN as corresponding member and as academician) [13]
Consultant posts (Americans only), type and location of institution, years in which the position was held
Party membership and posts (Soviets only), date of membership, type and location of party post, years in which the position was held

Each scientist was coded at least twice. Coding reliability averaged 94·8 per cent. for the Americans and 98·4 per cent. for the Soviets. Data files were stored on disc and tape. Missing data were reported on the print-outs and adjustments made for all frequency listings. We used the Statistical Package for the Social Sciences whenever possible.[14] In other instances original computer programmes (in FORTRAN IV) were developed. The data were processed on an IBM 370/145–VM computer, and separate runs were made for the 1970 and 1920–70 samples in each country.

I. Background Characteristics

We began our study with a comparison of the background characteristics of NAS and AN scientists. Did the Academy members resemble each other as scientific elites in 1970 and during the previous 50 years? We wanted to know whether the scientists in each Academy had similar types of employment. Also included was a description of their age, sex, and professional fields.

We found that the greatest similarity between Americans and Soviets was in their sex and age. In both countries the 1970 Academy members and the membership for the preceding 50 years were almost exclusively

[10] Place of birth was usually not available for Soviet scientists.
[11] For the Americans, we coded information on bachelor's, master's, and doctoral degrees. For the Soviets, we coded information on diploma, candidate, and doctoral degrees.
[12] Data on Soviet educational institutions were available only for the diploma.
[13] For use in another part of the study, we also coded the dates of election to republican academies of sciences, the USSR Academy of Medical Sciences, and the USSR Academy of Agricultural Sciences.
[14] Norman H. Nie, *et al.*, *Statistical Package for the Social Sciences* (2nd edition, New York: McGraw-Hill Book Company, 1975).

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male. (See Table 1.†) The average age for NAS and AN scientists in 1970 was 60–61 with a range of 34–37 to 92. A majority (55 per cent) of the NAS members in 1970 fell between the ages of 53–70; a majority (54 per cent) of AN members in the same year were slightly older, from 57–71. For a breakdown by different age groups see Table 2.

The similarities in sex and age do not carry over into professional fields. (See Table 3.) Here we see a contrast that emerged during the 50-year period and was quite noticeable by 1970. From 1920–69 the greatest difference between the NAS and AN members was in the proportion of chemists, but by 1970 the two Academies differed more substantially in their proportion of physicists and biologists. The professional fields of NAS members remained relatively consistent, but the fields of AN members had changed dramatically. The 1970 sample of AN members had almost twice as many physicists than the average for the preceding 50 years. Meanwhile, there were less than half the number of biologists and a 25 per cent reduction of chemists in the AN by 1970.

One of the issues receiving attention in Soviet literature on science is the professional employment of scientists in fields other than the ones in which they were educated.[15] This is reflected to a small degree in both Academies if we compare the above data with the major studies at doctoral level.[16] (See Table 4.) Among the 1970 AN scientists, 7·6 per cent. of those who received the Doctor of Biology degree were employed in other fields, most probably in physical and biochemistry. In fact, much of Soviet genetics and molecular biology during the 1950s was carried out under the aegis of the latter fields.[17] Meanwhile, the 1970 NAS scientists in physical and biochemistry seemed to have doctorates in chemistry. This was consistent with the educational patterns of American scientists and the developments in chemistry over the past 20 years.

To what extent do scientists in both countries have a technical training in their early educational backgrounds? To answer this question we compared undergraduate fields for recipients of the American bachelor's degree and of the Soviet diploma.[18] (See Table 5.) In the United States there was a trend towards scientists with degrees in the liberal arts, while in the Soviet Union the shift was towards scientists with diplomas in the technical sciences. Also, throughout the period of 1920–70, a much larger proportion of Soviet scientists graduated

† This and subsequent tables appear at the end of the paper.

15 See, for example, S. R. Kugel', " Professional'naya mobil'nost' v nauke i tendentsii ee izmeneniya v usloviyakh nauchno-tekhnicheskoi revoliutsii," *Voprosy filosofii*, No. 11 (1969), pp. 109–116.

16 The Ph.D. is closer to the Soviet candidate degree in years of education. However, we chose in this instance to compare doctor's degrees as indicative of the fields of professional training at the most advanced degree level in each country.

17 Mark Adams, *Genetics and the Soviet Scientific Community: 1948–65* (unpublished Ph.D. dissertation, Harvard University, 1972), pp. 186–235.

18 The Soviet diploma is actually between the American bachelor's and master's degrees in years of education.

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from polytechnical schools than was the case with American scientists. (See Table 6.) Given the sample sizes, the differences in percentage were significant at the ·05 level.[19] Differences in the professional fields of NAS and AN scientists are compounded, therefore, by contrasts in the proportion of Academy scientists with technical educational backgrounds.

Considering the elite status of both Academies, one would expect the scientists to have graduated from the most prestigious educational institutions.[20] In 1970 a comparable majority of them had not done so at the undergraduate level (i.e. 54·9 per cent for the NAS and 53·8 per cent for the AN). Nevertheless, the rest of the Academy scientists graduated from top universities, representing less than 1 per cent of the higher educational institutions in their respective countries.[21] Moscow State University (MGU) alone accounted for 33·7 per cent of the diplomas among Soviet scientists in 1970, while Berkeley, the California Institute of Technology, the University of Chicago, Columbia, Harvard, the Massachusetts Institute of Technology and the University of Wisconsin together accounted for 30·8 per cent of the American bachelor's degrees. (See Tables 7 and 8.)

More interesting, perhaps, is a comparison of the 1970 members with the deceased members. The NAS showed signs of becoming more elitist in the sense that the 1970 members were more likely to have started their education in top universities (45·1 per cent for 1970 members compared with 40·1 per cent for the deceased). Meanwhile, the opposite tendency prevailed in the Soviet Academy. Only 46·1 per cent of the 1970 AN members came from MGU or Leningrad State University (LGU), compared with 61·2 per cent of the deceased. The most substantial decline occurred in graduates from LGU, where more

[19] Throughout the paper, comparisons of percentages are based on the "Table of Significant Differences Between Percentages" in William Buchanan, *Understanding Political Variables* (New York: Charles Scribner's Sons, 1969), pp. 85–88.

[20] We considered Moscow State University and Leningrad State University as the most prestigious in the Soviet Union, although others could be added for particular fields. In the United States there was considerable overlap among the top-ten in physics, the top-ten in biology, and the top-ten in Chemistry. Cumulatively they constituted sixteen Universities and were coded separately as follows: University of California at Berkeley, University of California (other campuses), California Institute of Technology, University of Chicago, Columbia, Cornell, Harvard, University of Illinois, Johns Hopkins, Massachusetts Institute of Technology, University of Michigan, Princeton, Rockefeller University, Stanford, University of Wisconsin, and Yale. This list was derived from an analysis of the following sources: Allan M. Carter, *An Assesment of Quality in Graduate Education* (American Council on Education: Washington, D.C., 1966); R. Hughes' Study, reprinted in *American Universities and Colleges* (American Council on Education: Washington, D.C., 1928); H. Keniston, *Graduate Study in the Arts and Sciences at the University of Pennsylvania* (University of Pennsylvania Press: Philadelphia, 1959); Kenneth D. Roose and Charles Anderson, *A Rating of Graduate Programs* (American Council on Education: Washington, D.C., 1970).

[21] In 1970 there were 2,525 institutions of higher education in the United States and 805 in the Soviet Union. US Department of Commerce, *Historical Statistics of the United States: Colonial Times to 1920*, Part I (Washington, D.C., Bureau of the Census, 1975), p. 382; Tsentral'noe statisticheskoe upravlenie pri Sovete Ministrov SSSR, *Narodnoe khozyaistvo SSSR v 1974 g.* (Moskva: "Statistika," 1975), p. 687.

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scientists had been educated before 1917. The difference was not offset by an increase (only 3·5 per cent) in graduates from MGU. The 1970 AN members came instead from other institutions in Moscow. In part, this reflected the growing number of higher educational establishments in the Moscow area.

With the advancement of science and technology and the concomitant growth in the education systems of modern societies, we would expect an increase in the number of Academy members with doctoral degrees. Indeed, this was the case.[22] When contrasted with averages for the preceding 50 years, the proportion of NAS and AN scientists with the doctorate in 1970 was statistically significant. In the United States the increase was from 89·1 per cent to 98·5 per cent, and in the Soviet Union the change was more dramatic, from 33·1 per cent to 71·6 per cent. This is particularly impressive when compared with the national averages. Less than 0·003 per cent of the American and Soviet populations had a doctor's degree in physics (maths), chemistry, or biology in 1970.[23]

The institution where one receives the doctor's degree is generally more important for career opportunities and placement in the United States than where one receives the BA. As anticipated, American scientists received their doctoral degrees from fewer of the top-16 institutions than their bachelor's degrees, with Harvard the most dominant (especially in the 1970 sample). (See Table 9.) A smaller proportion of the doctorates came from outside the top-16 universities, whereas more came from foreign institutions as opposed to bachelor's degrees. Just as for the undergraduate level, however, the 1970 membership received their doctoral degrees from fewer educational institutions than the previous average. This seems to indicate that the NAS has been recruiting its membership from a narrower institutional base.

The regional distribution for undergraduate and graduate degrees reflected the traditional differences in the two countries and was consistent with the above findings on educational institutions. A greater proportion of the earlier AN members were educated in Leningrad (44·3 per cent), while the 1970 members were more likely to come from Moscow (47·6 per cent). (See Table 10.) No single city or state had the same concentration of graduates with a bachelor's degree in the United States. (See Tables 11 and 12.) However, the three most frequent states (California, Massachusetts, and New York) together accounted for 49·5 per cent of the doctoral degrees and 39·8

22 4·5 per cent of the NAS scientists and 1·5 per cent of the AN scientists (1920–70) had at least two doctor's degrees. However, data for only the first doctorate are reported in our Tables.

23 US Department of Commerce, *Historical Statistics*, op. cit., pp. 8 and 387; Tsentral'noe statisticheskoe upravlenie, *Narodnoe khozyastvo 1974*, op. cit., p. 7; D.M. Gvishiani, *et al. Nauchno-tekhnicheskaya revoliutsiya i izmenenie struktury nauchnykh kadrov SSSR* (Moskva: Izdatel'stvo " Nauka," 1973), p. 81.

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per cent of the bachelor's degrees among the 1970 NAS members.[24] Again, there was more of a concentration in fewer states for the 1970 members of NAS than for the deceased sample.[25] There was also a shift in the number of degrees obtained from foreign institutions. A European education at the doctoral level remained strong in the 1970 sample, but there were considerably fewer doctorates from Germany than the previous average.

A comparison of the role distribution of Academy members reveals the differences in the employment institutions of the two scientific elites. In both the NAS and AN most of the 1970 members had held at least one research position throughout their careers (90·4 per cent of the Soviets, 95·3 per cent of the Americans). Among Soviet researchers, 59 per cent had been heads of laboratories, sections, or departments within research institutes and 77 per cent held a research position within the AN at some time in their careers. Among American researchers, only 24·7 per cent had been heads of laboratories, sections, or departments within research institutes. More (73·2 per cent.) had been research fellows and 75·7 per cent held research posts within universities. These figures clearly reflect the fact that research plays a major role in the development of scientific elites in both countries, with the AN members obtaining this experience in the Academy itself and the NAS scientists working primarily in universities.

The differences in institutions of employment are further evident in the contrasts between the 1970 NAS and AN scientists who were engaged in teaching. The proportions of scientists who held at least one teaching post throughout their careers was 60·2 per cent for the AN and 98·7 per cent for the NAS. Only 44·8 per cent of the Soviet teachers had held the position of professor; 36·4 per cent had taught in universities and 20·7 per cent in polytechnical institutes. Among American teachers, however, 92·1 per cent had been professors; 97·4 per cent had been in universities and 19·1 per cent in polytechnical institutes.

Scientists in both Academies had been exposed to some administrative experience (71·3 per cent of the Soviets, 84·3 per cent of the Americans), but in different types of organizations. Within the USSR Academy, 28·7 per cent were directors of AN institutes, 16·1 per cent were members of AN commissions or councils, and 6·1 per cent were academician-secretaries. Outside the Academy, 14·9 per cent chaired departments in universities and 7·7 per cent chaired departments in polytechnical institutes. Among American administrators, however,

[24] Although there was more of a geographical dispersion of educational institutes in the United States by comparison with the Soviet Union, a majority of American bachelor's degrees came from only five states (California, Massachusetts, New York, Illinois, and Pennsylvania).

[25] The main change over time was the drop of New York (especially Columbia) to second place and the rise of California (especially Berkeley and Cal Tech) to first place.

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17·7 per cent had held their posts in private foundations, while 32·8 per cent were chairmen of university departments and 3·8 per cent were chairmen of departments in polytechnics. There was a contrast also in the proportion of Academy scientists on editorial boards of professional journals or encyclopaedias (22·2 per cent and 34·9 per cent of Soviet and American scientists with administrative experience, respectively) and a greater difference in the percentage who served as officers in professional associations (9·6 per cent and 52·6 per cent of Soviet and American scientists with administrative experience, respectively).

More than three-fourths of the NAS members (77·7 per cent) held at least one consultant post during their careers, most of which (68·7 per cent) were with the government. Separate posts of "consultant" were rarely included in the Soviet biographical data. Scientists within the AN advise the government regularly through their positions as Academy administrators and some have direct access to the USSR Council of Ministers' State Committee for Science and Technology. Only 15·3 per cent of the 1970 AN members had held an official government post. A larger percentage (42·9 per cent) were members of the Communist party, but only a tenth of these (4·2 per cent) had ever held a party post.

The above comparisons of background characteristics indicate that NAS and AN scientists were similar in sex, age, and educational profiles, but not in professional fields. The Soviet Academy was dominated in 1970 by physicists and by scientists with some technical training, while the NAS had more chemists and biologists. The elite orientation of both samples was evident in the proportion of scientists with doctorates and in the representation of the top schools in their educational backgrounds. The tendency in the United States, however, was for NAS members in 1970 to have graduated from fewer educational institutions than previously, whereas the 1970 AN members had not.[26]

The comparison of employment positions reflected the different organizations of science in each country. In the Soviet Union, for example, research positions were held most often in the Academy itself, whereas the American scientists generally conducted their research in universities. This was due to the fact that, in contrast to the NAS, the USSR Academy of Sciences is a research institution and AN members are usually its employees. Research is carried out in Soviet universities too, but they have lacked the prestige and material support of AN laboratories and have not attracted the best scientific personnel. The longer standing tradition of scientific research in American universities coincides with the greater proportion of NAS members who were also

[26] As a further indication of elitism among NAS scientsts, 75–78 per cent of all their employment positions in higher educational institutions between 1920–70 were in the top-ten schools of their own fields (75·4 per cent for the physicists, 78·4 per cent for chemists, and 75·3 per cent for the biologists).

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teachers. American scientists were more frequently affiliated with universities even in their administrative positions. While American universities and the Soviet Academy systems differ in their primary functions and government connections, we should not let this obscure the fact that the AN also engages in teaching, and the US government supports university research with grants and contracts.

II. Institutional Mobility

One characteristic that can be examined on the basis of biographical data is the career mobility of scientists in each country. As used in this paper, the concept does not assume a pattern of upward mobility in terms of promotions in rank. It focuses instead on movement between different types of institutions and regions where scientists have been educated and employed. Career mobility refers also to the frequency of movement to different types of institutions and regions throughout one's career.

The careers of scientists are circumscribed by institutions that are part of the country's social and political environment. Soviet R & D takes place in the Academies of Sciences, higher educational establishments, industrial enterprises, government ministries and departments; American R & D is carried out in universities, private industries, government laboratories and departments. It could be argued, however, that some of these differences are more apparent than real.

One could say that there is greater freedom and professional choice in the United States, which results in a higher degree of institutional mobility among American scientists and a greater diversity of employment trends. If it is true that there is more institutional autonomy in the United States, then the movement of NAS scientists from one type of organization to another should not follow any particular pattern. An alternative measure of institutional autonomy would be a significant negative relationship between different types of employment institutions. We examined the career mobility of scientists as an indication of the extent to which there was institutional autonomy and/or interrelationships among the organizations of science in each country. It was our contention that there were close institutional ties in the United States as well as in the Soviet Union and that the only significant difference in the career mobility of scientists was the greater tendency for AN scientists to remain in the same institutions throughout their careers.

We divided the study of institutional mobility into three parts. First, we examined the relationship between a scientist's institution of employment and the type of institution where he received his education. Secondly, we looked at the extent to which scientists were employed in the same type of institution throughout their entire careers. Thirdly, we focused on relationships among different types of employment institutions.

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A. Institutions of Education and Institutions of Employment

The general hypothesis for this section was that in each country certain types of employment institutions recruited scientists from specific types of educational institutions. For Soviet scientists the educational institutions were: universities, polytechnical institutes, medical or agricultural institutes, and the top-two higher educational establishments.[27] For American scientists the educational institutions were: state universities and colleges, private universities and colleges, polytechnical institutes, foreign educational establishments, the top-sixteen institutions, and the top-ten universities in one's field.[28]

In order to control for the possible effects of professional role or professional field, we subdivided the Soviet and American samples first into researchers, teachers, and administrators (disregarding professional fields) and, secondly, into physicists, chemists, and biologists (disregarding professional roles). The types of educational institutions remained the same for each professional role and field, but the types of institutions in which researchers were employed differed from those in which teachers and administrators were employed.

The data were divided further into five-year periods from 1920–70.[29] The *n* for each cross-tabulation of employment and educational institutions among researchers represented the total number of scientists employed in research positions within that five-year period. The *n* for teachers, administrators, and each professional field were computed similarly. The column marginals represented certain types of employment institutions and the row marginals represented certain types of educational institutions. For each scientist the educational data had to precede his employment data by at least one year.

For the hypothesis that employment institutions recruited their personnel systematically from scientists with a particular kind of educational background, we used a chi-square test for each possible combination of educational and employment institutions within each five-year period.[30] This told us whether institutions of employment and education were related to each other significantly more than one would expect by chance,[31] and whether the relationship persisted over time.

Education and Employment Mobility of Researchers

The types of institutions at which research scientists were employed in the Soviet Union were universities, polytechnical institutes, the

[27] MGU and LGU.

[28] See note 18.

[29] The extra year was included in the first period: 1920–25, 1926–30, 1931–35, 1936–40, 1941–45, etc.

[30] In most cases the *n* was large enough for regular Chi-square. The Fisher Exact Test was used for samples under 30.

[31] We are reporting as "significant" the relationships that were statistically significant at the ·05 level or less. For those cases where we have directional hypotheses, we have also recorded the results that were significant between ·05 and ·10.

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USSR Academy of Sciences, republican academies of sciences, medical or agricultural institutes, industrial and government establishments. In the United States researchers were employed in universities, polytechnical institutes, the top-sixteen educational establishments, private foundations, industry, government laboratories, and quasi-government or GOCO. institutions.[32]

We found that the USSR and republican academies of sciences tended to employ scientists who had received their diplomas from universities (rather than from polytechnical institutes), although this was statistically significant only between 1931–40 for the USSR Academy of Sciences and between 1956–70 for the republican academies. But the academies apparently drew their personnel from different universities. Scientists employed as researchers in the USSR Academy came from MGU, and *not* from LGU, more than would be expected by chance. Meanwhile, graduates of MGU were significantly *not* employed at the republican academies, thereby reinforcing the closer ties between MGU and the AN.

Although the academies are the main centres for basic research in the USSR, research is also conducted in higher educational and industrial establishments. Researchers in Soviet universities came mainly from MGU during the 1930s and the late 1940s, but that is the only period in which the relationships were significant. Research scientists at industrial enterprises came not only from the polytechnical institutes (1920–35, 1941–50), but also from MGU during much of the same period (1926–35, 1941–45). There was a shift of MGU graduates from employment at Academy institutes (1920–30) to employment at industrial and university research institutes in the 1930s and 1940s and then back to the Academy.

American scientists in industrial institutes came from a variety of educational backgrounds and they were less likely to have a polytechnical education.[33] NAS scientists who graduated from polytechnical schools usually became researchers in polytechnical institutes or government laboratories. In fact, American polytechnical institutes had a high degree of "inbreeding" throughout the period under study, i.e. at some time in their careers scientists with polytechnical training found research positions in polytechnical institutes more frequently than one would expect by chance. In the Soviet Union a similar degree of inbreeding occurred in medical and agricultural institutes, but not elsewhere.

[32] GOCO refers to those organizations that are "government owned, contractor operated." They are usually affiliated with universities and include: Argonne National Laboratory, Brookhaven National Laboratory, Jet Propulsion Laboratory, Lawrence Radiation Laboratory, Los Alamos Scientific Laboratory, National Accelerator Laboratory, Naval Arctic Laboratory, Oak Ridge National Laboratory.

[33] This was consistent with the general background of the entire sample as noted above.

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Education and Employment Mobility of Teachers

In both countries polytechnical institutes consistently recruited a significant proportion of their teachers from polytechnical schools, and universities recruited from universities (especially from MGU and LGU). In the United states, teachers in the top-sixteen institutions were drawn predominantly from graduates of those top-sixteen institutions. Teachers in Soviet universities tended to come from MGU and LGU, but teachers in Soviet polytechnical institutes did not. Thus, the tendency for Academy scientists in both countries was to teach at the same type of institution where they had been educated.

Education and Employment Mobility of Administrators

Academy scientists in administrative posts had more diversified educational backgrounds than those in reseach or teaching. NAS scientists were employed as administrators in universities, polytechnical institutes, industry, government, the National Academy of Sciences, and GOCO laboratories. AN scientists held administrative positions in universities and other higher educational establishments, the USSR and republican academies of sciences, industry, agricultural and medical institutes.

We hypothesized that the USSR Academy of Sciences would draw its administrative personnel from scientists who had entered the Academy from the more prestigious educational establishments, particularly from MGU and LGU. However, we found no discernible pattern in the Academy except for the period 1966–70, when the tendency was for Academy administrators to have received a polytechnical education.[34] This coincided with the period in which the government tried to re-orientate the Academy towards applied research.[35] A more persistent and earlier trend, however, was the employment of scientists with polytechnical training as administrators in industry (1931–50). By contrast MGU and LGU graduates were more likely to be administrators in universities (1920–65). This suggested two different career tracks for administrators: those in industry had a polytechnical background and those in universities came from the top-two universities in the country.

There was a greater consistency in the educational backgrounds of NAS scientists in administrative positions, as compared with those in teaching or research. Regardless of the employment institution, administrators tended to come from prestigious schools more than one would expect by chance. In other words, relationships were statistically significant between education in a top-sixteen institution and employment as an administrator in any one of the following: a university,

[34] Academy administrators during this period may have come from those who had been recruited into the Academy during the 1930s.

[35] See Linda Lubrano Greenberg, "Soviet Science Policy and the Scientific Establishment," *Survey*, No. 4 (1971), pp. 51–63, and No. 1 (1972), p. 127.

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a polytechnical institute, industry, government, GOCO laboratories, and the National Academy of Sciences. Throughout the period of our study a significant proportion of university administrators also came from foreign institutions.

Education and Employment Mobility of Scientists According to Professional Fields

How important is one's professional field to the mobility between educational and employment institutions? The coding of the American data enabled distinctions between the top-ten institutions in physics, in chemistry, and in biology to emerge. Employment by a top-ten institution in one's own professional field was related consistently to a prior education at a top-ten institution in the same field, regardless of whether employment was in research, teaching, or administration. For researchers this was the *only* employment pattern, i.e. there was a significant negative relationship between research employment in a top-ten institution in one field and graduation from an institution that was in the top-ten of another field. By contrast, the top-ten chemistry institutions employed teachers from the top-ten in physics; and there were no significant negative relationships between administrators who worked in a top-ten institution in one field but who graduated from a top-ten institution in another.

For AN scientists the professional fields were analyzed by repeating the same cross-tabulation procedure used earlier, combining the research, teaching, and administrative posts and dividing the sample instead into groups of physicists, chemists, and biologists. We found that Soviet universities employed university graduates regardless of their professional fields, and polytechnical institutes employed polytechnical graduates in physics and chemistry. After 1931 the USSR Academy of Sciences employed chemists who had graduated from a group of five schools [36] more than one would expect by chance, but republican academies significantly did not. These are similar to our earlier findings and indicate that (except for American researchers in the top-ten schools) one's professional field does not alter the relationships between educational and employment institutions as much as one's professional role.

B. Employment in the Same Type of Institution

One of the central elements of institutional mobility is the extent to which scientists move from one type of employment institution to another. Before examining the mobility of scientists between specific pairs of institutions, we compared the number of scientists who spent their entire careers in only one type of instition with those who worked

[36] Leningrad State University, Moscow State University, Leningrad Polytechnical Institute, Moscow Institute of Fine Chemical Technology, and Kazan University.

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in two or more types. Alternatively, we looked at Academy members who held at least 75 per cent. of all their posts in the same type of institution. Our hypothesis was that in each case the NAS scientists would have greater institutional mobility than their counterparts in the Soviet Union.

Number of institutions in which scientists were employed

The types of institutions used at this stage of our analysis were as follows: universities, polytechnical institutes, industry, and government (for scientists in both countries). To the American samples we added those in GOCO laboratories, the NAS, and private foundations. For the Soviets, we included medical and agricultural institutes, and the USSR and republican academies of sciences. We counted the number of scientists employed in one or more of the above institutions, and then compared the differences between the NAS and AN while checking professional fields.[37]

The percentage of Soviet scientists in the 1970 sample who had worked in only one type of institution throughout their careers was significantly greater than for the NAS scientists and earlier members of the AN. This was sufficient to prove our hypothesis correct (with reference to one type of institution). Differences in the employment of American and Soviet scientists in *more* than one organization were not statistically significant. (See Table 13.) Indeed in both countries over three-fifths of the Academy members had worked in two or three types of institutions (66·2 per cent of the Americans, 62·2 per cent of the Soviets). Nevertheless, the greater immobility of the 1970 AN scientists (compared with NAS scientists in 1970) appeared to be part of a trend towards less institutional mobility of scientists within the Soviet Union.[38] Such a tendency was evident through an internal comparison of the 1970 and deceased AN samples. By contrast, there seemed to be an *increase* in the mobility of American scientists, i.e. the 1970 NAS members were employed in more institutions than their predecessors, although the differences were not statistically significant.

When each sample was separated into physicists, chemists, biologists, physical chemists, bio-chemists, and bio-physicists, we found that Soviet physicists accounted for much of the immobility of AN members between 1920–70. (See Table 14.) The contrast was substantiated further by the significantly larger percentage of physicists in the

[37] Since some scientists held positions outside these institutions, we have in effect measured mobility among the above (most prevalent) types of institutions and not total institutional mobility. This accounts for 81·0 per cent of all American positions, and 82·1 per cent of all Soviet positions. Of the remaining positions, 53·5 per cent (NAS) and 14·5 per cent (AN) were in professional societies, and 27·6 per cent (NAS) and 23·5 per cent (AN) were on editorial boards. The rest were miscellaneous or indeterminate.

[38] Compare also the deceased Soviet and American members in Table 13. Apparently there were more AN than NAS scientists employed in three or four institutions during an earlier period.

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United States who were employed in four types of institutions throughout their careers. A greater proportion of the American physicists and chemists worked in three or four institutions and more American biologists worked in only one or two institutions. The reverse was true for the Soviets. In other words, American physicists and chemists were more mobile than their Soviet colleagues, while American biologists were less mobile.

Percentage of Posts in the Same Institution

While a scientist may have worked in only one of the institutions listed on the preceding page, this may not have represented 100 per cent of all his positions. He may have been employed also by an organization not included above. As a separate measure, therefore, we compared the proportion of NAS and AN members who remained employed in the same type of institution throughout their entire careers. (See Table 15.) We found that a significantly greater percentage of the 1970 Soviet sample had held 100 per cent of its employment posts in one type of institution (76·2 per cent of them in the AN). This supports the hypothesis of AN scientists being less mobile than the Americans and seems to reflect the recruitment of AN members from within the Academy. However, it also represents a statistically significant decrease in the mobility of Soviet scientists when compared with the average of the preceding 50 years.

When we extended our comparison to those who had held at least 75 per cent of their positions in the same type of employment institution, the differences between Soviet and American scientists were no longer as great. In both countries the 1970 Academy members were significantly less mobile than the average of the preceding 50 years. Combining this with our previous findings on the institutional mobility of NAS scientists, we see that while scientists in the 1970 American sample were less likely than earlier members to be employed in only one or two types of institutions, a significantly greater proportion of them remained in the same institution for at least three-fourths of their careers.

C. Contacts Between Employment Institutions

Finally, we considered whether employment in one institution was related significantly to employment in another, i.e. is there a pattern of mobility between certain types of institutions? [39] In the Soviet case we found that there was a significant negative relationship between employment in the USSR Academy of Sciences and employment in universities, polytechnical institutes, republican academies of sciences, and the government, i.e. scientists who were employed in the Academy

[39] We used the types of employment institutions listed earlier. Results are reported for the combined (1920–70) samples only, unless indicated otherwise.

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tended not to have been employed elsewhere. This was less true, however, for the 1970 members, which may reflect the relative decline in the Academy's institutional autonomy since 1965.[40] Meanwhile, throughout the period of our study, there was a significantly close tie between employment in republican academies of sciences and government institutions. Employment in government laboratories was related also to employment in industrial establishments, which was related in turn to employment in polytechnical institutes. The high mobility of scientists among these institutions was in sharp contrast to the low permeability of the USSR Academy and emphasized the latter's distinct institutional status.

There were fewer significant relationships among employment institutions for scientists in the United States. Employment in the National Academy was related to employment in private foundations, GOCO and government laboratories more than one would expect by chance. Mobility between government and industry was significant for the combined sample, but for the 1970 members employment in government was related more to employment in the top-16 educational institutions. The relative lack of significant relationships between American institutions indicated much less of an employment pattern for American scientists than for the Soviets.

Returning to our original set of hypotheses on institutional mobility, we see that both of them have to be modified. We first postulated that the career patterns of scientists would reveal close institutional ties in the United States as well as in the Soviet Union. The foregoing discussion has shown that this was true for relationships between the scientists' educational and employment institutions but not among the employment institutions themselves. For each type of role and professional field, scientists who held positions in certain kinds of employment institutions tended to have graduated from certain types of educational institutions more than would be expected by chance. The American and Soviet patterns resembled each other most closely for scientists in teaching roles. Furthermore, the greatest number of institutional ties was found among NAS scientists who held administrative positions. And regardless of role, employment in one of the top-ten universities was related significantly to graduation in a top-ten university in the same field.

By contrast, there did not seem to be any particular pattern when NAS scientists moved from one employment institution to another. This supported the argument that employment institutions were relatively more autonomous in the United States than in the Soviet Union, if we define institutional autonomy in terms of the absence of significant relationships. According to the alternative definition, however, the USSR Academy of Sciences was relatively autonomous by

[40] See Lubrano Greenberg, op. cit.

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virtue of the systematic low mobility between it and other places of employment.

The second hypothesis suggested that AN scientists would be less mobile in general than their American counterparts. This was true for the 1970 NAS and AN scientists and seemed to be reinforced when the 1970 samples were compared with previous members. However, the modifications apparent from our data were that more than three-fifths of the scientists in both Academies remained employed in only two or three types of institutions throughout their careers and a statistically significant proportion of the 1970 samples had held at least 75 per cent of their positions in the same type of organization. These findings suggest a relatively low degree of mobility between institutions of employment for scientists in both Academies, despite the contrasts and trends noted above.

III. Regional Mobility

As a parallel to our interest in institutional mobility, we were concerned also with the regional mobility of scientists in both countries. Soviet authorities have complained repeatedly about the excessive concentration of science in Moscow and Leningrad. Attempts have been made to redistribute Soviet scientific personnel and to establish regional centres of science in different parts of the USSR. The most notable science centre outside European Russia is the Siberian Division of the USSR Academy in Novosibirsk, and the Ukrainian Academy of Sciences has an important concentration of scientific resources in Kiev. By contrast, scientific research in the United States is not concentrated in an All-Union Academy nor in regional academies, and there are a greater number of universities spread throughout the country. The science centres at Cambridge, Berkeley, and Chicago have employed a greater proportion of NAS scientists than have other cities, but we would still expect American scientists to be more mobile than their Soviet colleagues.

With regard to regional mobility, we hypothesized that there would be a greater insularity of regions in the Soviet Union and less career mobility among AN scientists in general. We divided this section into three parts: (1) relationships between the region in which a scientist was educated and the region of his employment; (2) the extent to which a scientist remained employed in the same region throughout his career; and (3) the mobility of scientists between employment institutions in different regions.

A. Regions of Education and Regions of Employment

For each American scientist, the states in which he was educated and employed were coded separately and then grouped into the following regions: New England, Middle Atlantic, South Atlantic, East-South Central, West-South Central, East-North Central, West-

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North Central, Mountain, and Pacific.[41] We also coded employment in Canada, Europe and other countries. The geographical distinctions for Soviet scientists were Moscow, Leningrad, Novosibirsk, the rest of the RSFSR, the Ukraine, and other republics. Employment was held also at the all-Union level and in international organizations.

The patterns of regional mobility were found to be consistent regardless of professional roles.[42] Throughout the entire period of our study, Soviet scientists tended to be employed in the same region where they had been educated (i.e. those educated in Moscow worked in Moscow, those educated in the Ukraine worked in the Ukraine). The only statistically significant movement was between Moscow and Leningrad, and between Moscow and other parts of the RSFSR.[43] The same insularity of regions was evident when the samples were divided into professional fields.

On the whole, American scientists were also employed in the same region where they had been educated. There were more cases of significant relationships between different regions than in the Soviet case, but mobility was limited usually to adjacent areas. Scientists were unlikely to transfer between distant regions in any regular pattern. There was a negative relationship, for example, between education in New England or the Mid-Atlantic states and employment on the West Coast.

NAS scientists in teaching positions were more likely (than researchers or administrators) to be employed in the same region where they had been educated. An exception was the employment of teachers in the Mid-Atlantic before 1945; a significant proportion came from schools in the East-North Central (1920–45) and Mountain states (1926–40). However, researchers were employed in the region of their education only in New England, the Mid-Atlantic, East-North Central states, and the Pacific. There was a significant movement of researchers from education in East-South Central states to employment in the Pacific region from 1941–70. Administrators educated in the Pacific tended to stay employed there, and after World War II administrators in the Mid-Atlantic, West-South Central, and Mountain states were also working where they had been educated. Nevertheless, the number

[41] The following states were included in each region: *New England*: Connecticut, Massachusetts, New Hampshire, Rhode Island, Vermont; *Middle Atlantic*: New York, New Jersey, Pennsylvania; *South Atlantic*: Delaware, Maryland, District of Columbia, Georgia, Florida, Virginia, West Virginia, North Carolina, South Carolina; *East South Central*: Alabama, Kentucky, Mississippi, Tennessee; *West South Central*: Arkansas, Louisiana, Oklahoma, Texas; *East North Central*: Indiana, Illinois, Michigan, Ohio, Wisconsin; *West North Central*: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota; *Mountain*: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming; *Pacific*: Alaska, California, Hawaii, Oregon, Washington. US Department of Commerce, *Statistical Abstract of the United States*, 1975 (96th edition; Washington, DC: US Government Printing Office, 1975), p. 12.

[42] The data were subjected to Chi-square and Fisher Exact Tests as described earlier.

[43] There was some movement from education in Moscow to employment in republics other than the RSFSR and the Ukraine after World War II (1946–50) and more recently (1966–70).

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of scientists employed in the region of their education was significantly only half as frequent for researchers and administrators than for teachers.

When divided into professional fields, we saw a movement of physicists from education in the South Atlantic and East-South Central states to employment in the West-North Central states. The biologists were the least mobile, being employed in their region of education almost continuously except for an early employment in the Mid-Atlantic states of biologists from the Mountain region (1926–45) and a significant movement from education in the South Atlantic (1936–45, 1961–70) and East-South Central states (1941–45, 1951–55, 1961–70) to employment in the Pacific region.

B. Employment in the Same Region Throughout One's Career

We hypothesized that there was significantly less regional mobility among AN scientists than among NAS scientists. To test this, we compared the proportion of scientists in each sample that had been employed in one or more regions throughout their entire careers. The results showed that a significantly greater percentage of Soviet scientists remained employed in one or two regions, whereas the Americans tended towards employment in four, five or six regions. (See Table 16.)

A comparison of the 1970 and deceased members reinforced some of our earlier findings on institutional mobility. A greater proportion of the 1970 AN scientists had been employed in only one or two regions, whereas more of the deceased AN members had worked in four or five regions. By contrast, 1970 NAS scientists were more likely to have worked in four to nine regions than had been the case previously. Again, this seems to indicate the culmination of opposite tendencies in each country.[44]

Through a further subdivision into professional fields (physicists, chemists, biologists, physical chemists, bio-chemists and bio-physicists), we found that the above hypothesis held for each field, with a significantly greater proportion of Soviet scientists in one or two regions and the American scientists in five regions. (See Table 17.) The greater mobility of American physicists was significant also for employment in from four to six regions, as was the mobility of American chemists to four regions and American biochemists and physical chemists to six regions. With these samples separated into professional fields, we compared the differences in per cent between Soviet and American scientists who had held at least three-fourths of their posts in the same region.[45] The differences remained statistically

[44] It is possible that the employment patterns of the 1970 Academy members were atypical of earlier trends, but such a sharp change in one year is unlikely. A further breakdown of the data would be necessary to delineate when the change occurred and how regularly it continued.

[45] The proportion of scientists holding 100 per cent of their posts in the same region is not reported separately, because it is the same as the first two rows in Table 16.

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significant, with more Soviet scientists than Americans holding at least 75 per cent of their employment posts in the same region regardless of professional field. (See Table 18.)

C. Relationships Among Employment Regions

If scientists in the United States were more mobile than Soviet scientists, where did this movement take place, i.e. was there a pattern of mobility from employment in one region to employment in another? We examined this question through cross-tabulations of regions where American and Soviet scientists were employed between 1920–70.

For American scientists there was a significant relationship only between the East-South Central and East-North Central regions (for the 1970 NAS members) and between the Mountain and Pacific regions (for the 1920–70 members). There were significant negative relationships among the East-North Central, New England, and the Mid-Atlantic states. Meanwhile, the South Atlantic states drew scientists from Latin American countries, and the Pacific employed a significant proportion of scientists from Germany.

In the Soviet case, Moscow was insulated significantly from other areas, i.e. for scientists in Moscow there was a tendency *not* to be employed in Leningrad, the RSFSR, or other republics (at different times in their careers).[46] We saw earlier that scientists educated in Leningrad were often employed in Moscow and vice versa, but once working in the capital they tended to stay there. As one would expect, scientists with All-Union posts generally came from (or returned to) employment in Moscow. The largest number of scientists with international scientific posts had other positions also in Moscow, but given the sample size a more significant proportion worked in Leningrad (57·9 per cent) and in the Ukraine (26·3 per cent).[47]

The above data demonstrate, therefore, that AN scientists were not as mobile during their careers as were NAS scientists. This was not surprising, given the employment of many AN scientists in the USSR Academy. However, the first part of our hypothesis was less clearly substantiated. The insularity of regions was generally more prevalent in the Soviet Union than in the United States. However, there was significant movement between the educational and employment institutions of Moscow and Leningrad, and much of the mobility of NAS scientists was actually between adjacent regions.[48] Furthermore,

[46] The negative relationship between employment in Moscow and Leningrad was highly significant (at the ·0000 level) and consistent for the 1970 and combined samples (1920–70).

[47] From 1920–70, 26 scientists with international posts were employed in Moscow, but this was not statistically significant. Employment in the Ukraine was related significantly to international posts for the combined sample (1920–70) but not for the 1970 sample alone. Also, there was more mobility between the Ukraine and republics other than the RSFSR during an earlier period.

[48] Much of this depends, of course, on how one defines a "region." The RSFSR, for example, was separated into Moscow, Leningrad, and other parts of the republic.

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the NAS scientists who were teachers or biologists tended to work in the same region where they had been educated more than would be expected by chance. The same was true for researchers and administrators in New England, the Mid-Atlantic, and the Pacific. Finally, while the negative relationships between regions were not as marked in the Soviet Union, there was no significant mobility between non-contiguous regions of employment in the United States.

IV. Conclusion

How similar are the American and Soviet scientific elites in terms of their background characteristics and their institutional and regional mobility? To what extent are their careers a reflection of the different social contexts within which they work? How can we best summarize the results of the above comparisons?

With regard to background characteristics, we saw that NAS and AN scientists were most similar in age and sex, and a comparable proportion of them had graduated from the most prestigious schools in their respective countries. At the same time there was a greater dominance of physicists and more scientists with technical training in the Soviet Academy than in the NAS. This may reflect the fact that the Soviet Union was traditionally stronger in physics than in other fields and the AN recruited technical specialists into its membership from the 1930s through to the 1950s.

Employment institutions revealed the organizational contexts within which scientists carried out their research, teaching, and administrative roles. Despite the specific differences in bureaucratic structures, we hypothesized that there were close institutional ties in the United States as well as in the Soviet Union. We found that this was true for relationships between educational and employment institutions, but not among the employment institutions themselves. In the latter case, there was no regular pattern of mobility between American institutions. While this indicated greater institutional autonomy in the United States, an alternative measure of autonomy showed that employment in the USSR Academy of Sciences was related negatively to employment in other institutions more than one would expect by chance.

We hypothesized further that there would be greater degrees of institutional and regional mobility in the United States than in the Soviet Union. This was observed by the number of institutions or regions in which Academy scientists were employed and by the proportion of scientists with more than 75 per cent of their employment positions in the same type of institution or region. A significantly greater percentage of Soviet scientists remained employed in the same institution or region throughout their entire careers. In both cases there was *less* career mobility among the 1970 AN members than previously, while the 1970 sample of American scientists tended to be *more* mobile than earlier NAS members. When we compared the

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proportion of scientists with at least 75 per cent of their posts in the same institution or region, however, we found that the difference was less significant between the Academies with regard to employment institutions (for the 1970 samples), but Soviet scientists still tended to have less regional mobility than their American counterparts.

Given the different traditions of centralization and decentralization in science and the different employment opportunities in each country, it is not surprising that there was relatively greater career mobility in the United States. However, we should be careful not to extend this generalization too far. It was evident from the above data that some of our hypotheses had to be modified and that there were important similarities between NAS and AN scientists as well as differences. Each relationship should be examined separately in the context of the time period when it occurred. We hypothesized, for example, that there would be a greater insularity of regions in the Soviet Union. This was only partially true, since a significant proportion of the NAS scientists tended to work in the same region where they had been educated, and regional mobility in the United States was often confined to geographically adjacent areas.

Some of the similarities in the careers of scientists can be attributed to their professional roles and some of the differences to their social institutions. But this was not always the case. This institutional mobility of scientists in teaching roles was similar, for example, but there were different employment patterns for scientists who were researchers. The implication here is that the institutional environments were more important for career mobility than professional roles. In both countries the teachers were employed by educational establishments, which share certain similarities in primary function and organization. However, the research roles were carried out, for the most part, in very different organizational structures, i.e. universities in the United States and the USSR Academy of Sciences in the Soviet Union.

Career mobility, in terms of the variables discussed above, is clearly a reflection of the different organizations of science in each country. Yet the similarities of professional roles and elite status are also evident. Our findings indicate that we should be cautious in accepting generalizations that exaggerate either the universal characteristics of science or the contrasts in social environments.

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TABLE 1

Sex of NAS and AN Scientists

Sample	Sex	NAS	AN
1970	Male	99·1[a]	98·9
	Female	0·9	1·1
1920–69	Male	99·4	99·3
	Female	0·6	0.7

[a] The figures in this Table and all subsequent Tables represent percentages.

TABLE 2

Age of Academy Scientists in 1970

Age Group	NAS (N = 470)	AN (N = 260)
30–39	1·3	4·6
40–49	15·3	13·8
50–59	32·8	23·8
60–69	25·7	37·7
70–79	18·7	17·3
80–89	6·0	3·1
over 90	0·2	0·4

TABLE 3

Professional Fields of NAS and AN Scientists

Field	NAS Scientists		AN Scientists	
	1970 (N=470)[a]	1920–69 (N=175)	1970 (N=261)	1920–69 (N=136)
Physics	26·0	26·3	43·7	22·1
Chemistry	19·8	24·0	26·4	35·3
Biology	30·0	38·9	13·8	31·6
Physical Chemistry	9·8	4·0	9·6	6·6
Biophysics	2·8	0·0	0·0	0·0
Biochemistry	11·7	6·9	6·5	4·4

[a] In each case N refers to the full sample size for the years indicated.

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TABLE 4

Degree Fields at Doctoral Level for Academy Scientists

Field	NAS Scientists		AN Scientists	
	1970 (N=427)[a]	1920–69 (N=90)	1970 (N=187)	1920–69 (N=45)
Physics	25·5	25·6	43·3	20·0
Chemistry	28·3	25·6	27·3	35·6
Biology	28·3	32·2	21·4	33·3
Physical Chemistry	6·3	1·1	0·0	0·0
Biochemistry	5·9	6·7	0·0	0·0
Technical Sciences	0·0	0·0	6·4	2·2
Others	5·6	8·9	1·6	8·9

[a] In each case N refers to the number of scientists with data on doctoral field. Percentages represent adjusted frequencies.

TABLE 5

Types of Undergraduate Education for NAS and AN Scientists

Type of Degree	NAS Scientists		AN Scientists	
	1970 (N = 416)[a]	1920–69 (N = 157)	1970 (N = 248)	1920–69 (N = 129)
Bachelor of Science	50·5	54·8	—	—
Bachelor of Arts	45·9	40·1	—	—
Diploma in the Technical Sciences	—	—	23·8	16·3
Diploma in the Natural Sciences [b]	—	—	< 12·9	< 18·7

[a] In each case N refers to the number of scientists with data on types of undergraduate education. The Table lists adjusted frequencies.

[b] For the undergraduate diploma the field of mathematics was sometimes reported along with physics (maths), chemistry and biology.

TABLE 6

Academy Scientists Who Received Their Undergraduate Degrees from Polytechnical Schools

Sample	NAS	AN	Differences in per cent
1970	8·7	24·3	15·7 *
1920–69	3·8	15·3	11·5 *

* $p \leqslant 0{\cdot}05$.

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TABLE 7

Institutions From Which NAS Scientists Received Their Undergraduate Degrees

Institution	1970 (N = 415) [a]	1920–69 (N = 157)
Berkeley, Cal. Tech., Univ. of Chicago, Columbia, Harvard, MIT, Univ. of Wisconsin	30·8	24·2
Other Universities in the Top–16	14·3	15·9
Other American Private Colleges	27·0	24·2
Other American State Colleges	17·8	26·8
Other Educational Institutions (including foreign schools)	10·1	8·9

[a] In Tables 4 and 5, N refers to the number of scientists with data on undergraduate institutions. Both Tables list adjusted frequencies.

TABLE 8

Institutions from Which AN Scientists Received Their Undergraduate Degrees

Institution	1970 (N = 249)	1920–69 (N = 129)
Moscow State University	33·7	30·2
Leningrad State University	12·4	31·0
Leningrad Polytechnical Inst., Moscow Inst. of Fine Chemical Technology, Kazan University [a]	14·0	9·3
Other Educational Institutions (including foreign schools)	39·8	29·5

[a] These were the only institutions (besides MGU and LGU) that had more than five graduates in the AN membership.

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TABLE 9

Comparison of Institutions from Which NAS Scientists Received Their Bachelor's and Doctor's Degrees

Institutions	Degree	1970 Sample	1920–69 Sample
Five of the institutions in the top-16	Doctor's	46·5 [a]	43·9 [b]
All institutions in the top-16	Bachelor's	45·1	40·1
American institutions other than the top-16	Doctor's	11·7	10·3
	Bachelor's	47·0	51·6
Foreign institutions	Doctor's	14·1	18·7
	Bachelor's	7·9	8·3

[a] Harvard, Columbia, Berkeley, University of Wisconsin, Cal. Tech.
[b] Harvard, Columbia, Johns Hopkins, Yale, University of Chicago.

TABLE 10

Location of Diplomas for AN Scientists

Location	1970 (N = 246) [a]	1920–69 (N = 131) [a]
Moscow	47·6	37·4
Leningrad	25·6	44·3
RSFSR [b]	11·0	3·1
Ukraine	8·5	9·1
Other Republics [c]	6·1	0·0
Outside USSR	1·2	6·1

[a] N refers to the number of scientists with data on location of diplomas. Percentages represent adjusted frequencies.
[b] Not including Moscow and Leningrad.
[c] Uzbekistan, Armenia, Azerbaidzhan, Belorussia, Lithuania, Georgia, Kazakhstan.

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TABLE 11

Location of Bachelor's Degrees for NAS Scientists [a]

Location	1970 (N = 412) [b]	1920–69 (N = 155) [b]
California	12·4	5·2
Massachusetts	13·8	13·5
New York	13·6	7·1
Pennsylvania	6·3	4·5
Illinois	5·1	8·4
Missouri	3·9	7·7
Wisconsin	3·4	3·2
Michigan	2·9	4·5
New Jersey	2·4	2·6
Connecticut	2·4	3·2
Indiana	2·2	3·9
Maryland	1·5	3·2
Kansas	1·0	5·8
Texas	1·0	2·6
Canada	3·2	3·9
Europe [c]	3·9	3·2

[a] The Table includes only those that accounted for more than 2 per cent of the bachelor's degrees in one of the samples.
[b] N refers to the number of scientists with data on location of bachelor's degree. Percentages represent adjusted frequencies.
[c] Not including Germany.

TABLE 12

Location of Doctor's Degrees for NAS Scientists [a]

Location	1970 (N = 462) [b]	1920–69 (N = 154) [b]
California	17·5	9·7
Massachusetts	17·5	14·3
New York	14·5	14·3
Illinois	7·8	9·1
Wisconsin	7·1	3·2
New Jersey	3·5	3·9
Maryland	3·0	8·4
Connecticut	2·4	7·8
Michigan	2·4	1·3
Pennsylvania	2·4	1·3
Europe [c]	9·3	5·8
Germany	4·3	13·6

a The Table includes only those that accounted for more than 2 per cent of the doctoral degrees in one of the samples.
[b] N refers to the number of scientists with data on the location of their doctoral degree. Percentages represent adjusted frequencies.
[c] Not including Germany.

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TABLE 13

Number of Institutions in Which NAS and AN Scientists Were Employed

Number of Employment Institutions [a]	NAS Scientists 1970 sample (N=470)	NAS Scientists 1920–69 sample (N=175)	NAS Scientists 1920–70 (N=645)	AN Scientists 1970 sample (N=261)	AN Scientists 1920–69 sample (N=136)	AN Scientists 1920–70 (N=397)
1 type	15·5	< 19·4	16·6	31·0	> 12·5	24·7
2 types	33·8	< 37·7	34·9	34·5	< 36·0	35·0
3 types	32·1	> 29·1	31·3	23·4	< 34·5	27·2
4 types	13·6	> 9·7	12·6	9·2	< 14·7	11·1
5 types	4·9	> 2·3	4·2	0·0	< 2·2	0·8

[a] Represents the number of types of institutions in which scientists were employed throughout their entire careers.

TABLE 14

Number of Institutions in Which NAS and AN Scientists Were Employed by Professional Fields

Number of Employment Institutions [a]	Professional Fields [b]	NAS 1920–70 [c]	AN 1920–70 [c]	Differences in per cent
1 type	physicists	10·1	31·3	21·2 *
	chemists	12·6	23·1	10·5
	biologists	23·4	20·3	3·1
	others [d]	18·1	17·5	0·6
2 types	physicists	27·4	35·4	8·0
	chemists	28·1	39·3	11·2
	biologists	45·5	30·4	15·1
	others	34·6	31·6	3·0
3 types	physicists	32·7	25·0	7·7
	chemists	43·7	23·9	19·8 *
	biologists	20·1	34·2	14·1
	others	34·6	29·8	4·8
4 types	physicists	19·0	5·6	13·4 *
	chemists	13·3	12·0	1·3
	biologists	9·1	13·9	4·8
	others	9·0	19·3	10·3
5 types	physicists	10·1	0·7	9·4
	chemists	2·2	0·9	1·4
	biologists	1·4	1·3	0·1
	others	3·0	0·0	3·0

[a] Represents the number of types of institutions in which scientists were employed throughout their entire careers.

[b] The N for each field is as follows: NAS physicists = 168, chemists = 135, biologists = 209, others = 133; AN physicists = 144, chemists = 117, biologists = 79, others = 57.

[c] The combined (living and deceased) samples were used for each Academy: NAS = 645, AN = 397.

[d] Refers to biochemists, physical chemists, and biophysicists.

* $p \leqslant 0{\cdot}05$.

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TABLE 15

Percentage of Positions in the Same Type of Employment Institution

	100 per cent of all positions [a]	≥ 75 per cent of all positions [a]
NAS scientists:		
1970 sample	4·9	28·7
1920–69 sample	5·7	16·6
Difference in per cent for NAS	0·8	12·1 *
AN scientists:		
1970 sample	24·1	34·9
1920–69 sample	9·6	15·4
Difference in per cent for AN	14·5 *	19·5 *
Difference in per cent. between NAS and AN samples:		
1970	19·2 *	6·2
1920–69	3·9	1·2
1920–70	14·0	2·8

a Refers to the proportion of scientists who held 100 per cent (or ⩾ 75 per cent) of all their career positions in the same type of institution.
* $p \leqslant 0{\cdot}05$.

TABLE 16

Number of Regions in Which NAS and AN Scientists Were Employed

Number of Employment Regions [a]	Academy	Years of Samples 1970		1920–69	1920–70
1 Region	NAS scientists	3·0	<	4·0	3·3
	AN scientists	32·2	>	28·7	31·0
	Difference in per cent	29·2 *		24·7 *	27·7 *
2 Regions	NAS scientists	11·3	<	13·1	11·8
	AN scientists	42·1	>	35·3	39·8
	Difference in per cent	30·8 *		22·2 *	28·0 *
3 Regions	NAS scientists	20·6	<	28·0	22·6
	AN scientists	17·2	<	18·4	17·6
	Difference in per cent	3·4		9·6	5·0
4 Regions	NAS scientists	28·1	>	23·4	26·8
	AN scientists	5·7	<	15·4	9·1
	Difference in per cent	22·4 *		8·0	17·7 *
5 Regions	NAS scientists	19·4	>	18·3	19·1
	AN scientists	1·1	<	2·2	1·5
	Difference in per cent	18·3		16·1 *	17·6 *
6 Regions [b]	NAS scientists	11·7	>	9·7	11·2
	AN scientists	0·0		0·0	0·0
	Difference in per cent	11·7 *		9·7	11·2 *

a Represents the number of regions in which a scientist was employed throughout his entire career.
b 4·8 per cent of the NAS scientists (1920–70) were employed in more than six regions.
* $p \leqslant 0{\cdot}05$.

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TABLE 17

Number of Regions in Which NAS and AN Scientists Were Employed by Professional Fields

Number of Employment Regions [a]	Professional Fields [b]	NAS 1920–70 [c]	AN 1920–70 [c]	Differences in per cent
1 Region	physicists	4·8	42·4	37·6 *
	chemists	3·7	33·5	29·8 *
	biologists	2·3	19·0	16·6 *
	others	2·4	15·8	13·5 *
2 Regions	physicists	11·9	34·7	22·8 *
	chemists	11·1	41·0	29·9 *
	biologists	12·9	39·2	26·3 *
	others	10·5	50·9	40·4 *
3 Regions	physicists	25·0	16·0	9·0
	chemists	22·2	17·1	5·1
	biologists	20·1	17·7	2·4
	others	24·1	22·8	1·3
4 Regions	physicists	26·2	4·9	21·3 *
	chemists	31·1	6·8	24·3 *
	biologists	27·3	19·0	8·3
	others	22·6	10·5	12·1
5 Regions	physicists	16·7	0·7	16·0 *
	chemists	21·5	0·9	20·7 *
	biologists	18·2	5·1	13·1 *
	others	21·1	0·0	21·1 *
6 Regions	physicists	10·7	0·0	10·7 *
	chemists	7·4	0·0	7·4
	biologists	12·0	0·0	12·0
	others	14·3	0·0	14·3 *

[a] Represents the number of regions in which a scientist was employed throughout his entire career.

[b] The N for each field is as follows: NAS physicists = 168, chemists = 135, biologists = 209, others = 133; AN physicists = 144, chemists = 117, biologists = 79, others = 57.

[c] The combined (living and deceased) samples were used for each Academy: NAS = 645, AN = 397.

[d] Refers to biochemists, physical chemists, and biophysicists.

* $p \leqslant 0{\cdot}05$.

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TABLE 18

Scientists Holding at Least Seventy-Five per cent of Their Posts in the Same Region

Professional Fields [a]	NAS 1920–70 [b]	AN 1920–70 [b]	Differences in per cent
Physicists	16·7	53·5	36·8 *
Chemists	12·6	54·7	42·1 *
Biologists	11·5	38·0	26·5 *
Others [c]	15·0	35·1	20·1 *
All Fields Combined	13·8	48·1	34·3 *

[a] The N for each field is as follows: NAS physicists = 168, chemists = 135, biologists = 209, others = 133; AN physicists = 144, chemists = 117, biologists = 79, others = 57.

[b] The combined (living and deceased) samples were used for each Academy: NAS = 645, AN = 397.

[c] Refers to biochemists, physical chemists and biophysicists.

* $p \leqslant 0{\cdot}05$.

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Bertram David Wolfe
1896-1977

THAT Bertram D. Wolfe had written an enduring classic *Three Who Made a Revolution* was recognized as soon as it was published in 1948; Isaiah Berlin judged it as having "a degree of authority" unmatched by any similar book; William Henry Chamberlin said that it was "by far the best history of the Russian revolutionary movement available in English" while Edmund Wilson declared it "the best book in its field in any language." Now that Bert is no longer with us, the story should be told of how this gentle, courteous, and warm-hearted man became the penetrating student of the revolutionary spirit.

Bert Wolfe's formative years recapitulated those of Lenin and Trotsky. From the time he became a radical socialist in 1917, thereupon losing his post as a teacher in the Boys' High School in Brooklyn, New York, Bert lived for most of the next 13 years the fitful, tangential existence of an underground revolutionist. He was familiar with the faction fights, the agitation of party conferences, the wanderings in foreign capitals, the tactical duels with the secret police, the camouflage of false names, the sparse rations of food and shelter. Together with John Reed, Bert wrote the Manifesto of the National Left Wing of the Socialist Party which he still characterized proudly in his old age as "a document of largely native American radicalism." In 1924 he worked his way on a ship to the Fifth Congress of the Communist International, bearing a Mexican passport and the credentials of a representative of the Mexican Party. In the United States he had previously edited (under a pseudonym) a newspaper in San Francisco that was jointly financed by a curious directorate drawn from trade union leaders, the Irish Republican Movement, and the Hindu Gadir Party, the latter being mostly made up of revolutionary Sikhs. Chance and the "dialectic" intervened, however, so that he spent most of the early twenties working in the Mexican Communist Party and serving on its Central Committee. During these years Bert became the close friend and later co-worker of the painter Diego Rivera, who deeply influenced Bert's outlook towards art and nature. Meanwhile something of the political doubter emerged in Bert, for he persuaded Diego Rivera to resign from the Communist party. He felt that membership was helping neither Diego as an artist nor the party as an organization, and he actually won the Mexican comrades, at least temporarily, to his non-Leninist standpoint. Deported, however, from Mexico under some comic trumped-up

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charge, Bert was soon directing the American Communist campaign that was mounted on behalf of the Italian anarchists, Sacco and Vanzetti, then awaiting execution in Massachusetts; in later years he was to feel keenly that those like Carlo Tresca and Upton Sinclair who were sceptical of Sacco's innocence should have spoken out honestly. Soon the hectic years of the "faction" struggle within the Communist party began; Bert, at the time in charge of the Party's educational activities, also became editor of its official magazine *The Communist*. He supported the Party secretary and his fellow City College alumnus, Jay Lovestone, in advocating the so-called theory of "exceptionalism," according to which the strength and prosperity of American capitalism, together with its democratic political constitution and traditions, precluded the application in the United States of a revolutionary "line." Indirectly, the relative moderation of the Lovestone-Wolfe leadership made them sympathetic to the right-wing "deviation" that was arising in the Soviet Union around the figure of the cultured and ill-fated personality of Nikolai Bukharin. It was probably during this time that Bert came to realize that his own personality was not adaptable to the dishonesties and intricate manoeuverings of international communist politics. In December 1928, he went to Russia as the American representative on the Executive Committee of the Communist International. Despite his collapse under the strains of physical illness, Bert fought with all his resources to induce the Comintern to allow the American Communist party to go its own independent way. Stalin, however, remained adamant in demanding the ouster of the Lovestone-Wolfe leadership. Bert, still trusting in the power of logic and fact then cabled Lovestone advising that an American delegation should come to Moscow to argue face to face with the Bolshevik chiefs. Bukharin by this time had been removed from fulfilling any functions as Chairman of the International; he had been declared sick by a vote of five to four, as he told Bert. Thus Bert and the Americans fell into Stalin's trap. Stalin met with the Comintern's "American Mission," and laid down the condition of the Americans' capitulation; not satisfied with the simple acceptance of party discipline, he demanded the ouster of Lovestone and Wolfe from the leadership and that they should stay on indefinitely in Moscow. Stalin's outburst against the Americans during the main session was so violent and threatening that Bert never forgot it. The memory of it hovered over the pages that he later wrote concerning the social system of Soviet despotism. The Americans, shunned by the Russians, and always under surveillance, kept sending back cables to their American supporters (using all sorts of code names like I. M. Shmendrick, a Yiddish combination for "I am a fool") in an endeavour to retain their control of the party "institutions" and press. But it was to no avail against the combined force of Stalin's apparatus and the pusillanimity of the comrades at home. Lovestone and Wolfe were fortunate to escape from Moscow two months later

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without the knowledge of the Comintern. Whereupon the Russians called upon the American Party to condemn these disrupters. Bert came alone to a meeting of the Political Committee, and gave a speech that "absolutely astounded" those present with its defiance. He was the only one, as Theodore Draper recounts, who voted against the expulsion of Lovestone—who had enjoyed, half a year earlier, the support of 90 per cent of the Party. Shortly afterwards, when Bert refused to make a speaking tour on behalf of the Party's new "line," he was expelled from its membership.

During later years, I used to observe that the cardinal sin in Bert's eyes was "to run with the pack." He had seen the pack running in the Communist Party in 1929, and how the pack could be led. Slowly, as he said, he began to turn the "searchlight" on himself and his comrades to understand the laws of ideological commitment, the laws of the pack, for only by such understanding could he achieve freedom.

Bert seems to have reacted to the *débâcle* of his Communist experience by finding wisdom in the study of Spanish literature. Earning his living as a highly effective teacher at the Eron Preparatory School, he took a Master's degree in Spanish in 1931 at Columbia University with a thesis *The Mexican Ballad*, and became an authority on *Don Quixote*. The great translator. Samuel Putnam, has paid tribute not only to Bert's personal chivalry but to his magisterial judgment on questions of Cervantes scholarship. In Don Quixote Bert seems to have found the symbol of the intellectual's tilting at the windmills of history. Bert did not like to discuss religious-philosophical questions, and seemed devoid of any religious longing. However, the Spanish language and literature somehow provided him with the words in which such feelings could be voiced. He could quote the lines of Calderón, *La vida es un sueño*, but not stopping there, would recite whole passages. He later translated the poems of Leon Felipe, the poet of "Spain's exodus and tears," in whom he found, besides tragedy, the "thunder of the biblical prophets." He estimated Felipe's creed as "not unworthy of the vision of the mad Knight of La Mancha," citing his *Death's Calendar*:

> The pendulum has broken . . .
> Here let me sleep
> in nothingness. The nothingness that is
> the clock of the universe
> stopped forever.

The course that Bert gave at Stanford University in 1949 on *Don Quixote* during a year as Lecturer on Spanish Culture must have contained the essence of his personal philosophy.

THE fulcrum of Bert's political activity during the thirties was the "Communist Party of the USA (Opposition)" or the "Lovestoneites," as they were called in that era when proper names became

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the signposts of movements. In the nineteenth century, movements named themselves after doctrines, in such words as "impossibilists," "maximalists," and "reformists"; then later came the Russians using such procedural words as "Mensheviks," "Bolsheviks," and "Liquidators." In the thirties, however, proper names that became hyphenated, obscure, and sometimes allegedly illegitimate were introduced. Bert as Director of the New Workers School was in charge of educational activities. A big sign on a small building on 14th Street blazoned forth TRAINING FOR THE CLASS STRUGGLE; no school has ever summed up the philosophy of its curriculum so succinctly. Diego Rivera covered its dingy walls with murals on the history of the workers' movement, giving a notable place to Bert's meditative face. The "Lovestoneites" remained influential in New York's garment workers' unions, but among the intellectuals of the thirties they made little impression. For, as Bert once said, the leftist intellectuals of that decade tended to become Trotskyists; the severity of the American depression seemed to confute the notion of American "exceptionalism," while Trotsky's stirring, dramatic, personal brilliance made him an embodiment of the will to fashion a new world, and to withstand the Nazi barbarism. During this decade, Bert's creative energies were mostly devoted to the writing of his book *Diego Rivera, his Life and Times*, and to the texts that accompanied the plates of Rivera's murals in *Portrait of America* and *Portrait of Mexico*. Bert thus virtually wrote a brief history of the American radical movement, and a volume on the social history of Mexico that ended with an augury of the socialistic labour movement that would carry matters far beyond the Cardenas compromise. In addition, Bert published several memorable political essays, an incisively written pamphlet *What is the Communist Opposition?*, a booklet *Marx on America*, a pioneer essay in Marxist scholarship that blended with Bert's interpretation of American "exceptionalism," a book *Civil War in Spain* (1937), based on his visit to Loyalist Spain, and which included an introduction by Will Herberg, a translation of and introduction to Rosa Luxemburg's classic critique, *The Russian Revolution*, and then most important in 1939, *Keep America Out of War*, a book written with Norman Thomas, the leader of American socialism, which admonished *This is Not Our War!* and warned that if America entered the war, "decency, tolerance, kindliness, truth, democracy, and freedom will be the first victims," and that in the name of stopping totalitarianism, we would in fact be installing it in America. This book was scarcely being sold when Bert decided he had gone so essentially wrong on political fundamentals that he must start anew to re-examine his political postulates. Why had his political intelligence culminated in epochal blunder? How had he been misled by Marxist shibboleths to misunderstand American and world political realities?

Laboriously and courageously Bertram Wolfe undertook to study the

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whole significance of the Russian revolutionary movement and the Soviet State. He worked hard in middle age to master the Russian language, helped by the tutoring of Vera Alexandrova. He could never learn it as he knew Spanish; he said he never acquired a feeling for Russian poetry. But he made himself capable of using the language for original historical research. He acquired the tools of the historian's craft; he learned, as he said, how the sources should be used, and how the evidence should be impeccably marshalled. Through the war years and afterwards, Bert wrote and completed his masterpiece *Three Who Made a Revolution.* He had found his vocation; the ordeals of his own life imparted to his political knowledge the ingredient of human wisdom that gave a timeless aspect to this work. In its pages, the " truth of the defeated " stood alongside and indeed superior to the " official truth " as truth itself emerged.

Books and numerous articles then followed one another. With *Six Keys to the Soviet System* and *Khrushchev and Stalin's Ghost* Bert became America's leading political analyst of the Soviet Union. For four years Bert also served as Chief of the Ideological Advisory Staff of the State Department and the Voice of America, greatly enjoying the intellectual companionship he found in these circles. He liked to tell of the several instances in which his advice had helped to shape the decisions of national policy. Then came the opportunity to serve as a Visiting Professor of History at the University of California at Davis, in 1961–62. It also brought Bert an honorary degree, so that he joked that having never taken a doctor's degree, he had now gained an honorary one. He was given the degree because one day a member of the Board of Regents heard Bert lecture on the role of the Lysenko affair in Soviet genetics, a theme especially pertinent to the agricultural and biological faculties at Davis. The Regent was so impressed that he nominated Bert for the honour. Bert was a natural teacher; in fact, he enjoyed it so much that he wrote very little that year. He could have become a permanent member of the Davis faculty, but he decided that with his advancing years, and the books he wished to write, it was wiser for him to accept an offer to become a Fellow of the Hoover Institution.

When his colleague, Boris Nicolaevsky, died in 1966, Bert was asked to speak at his funeral. He told movingly how the old Menshevik had finally found at the Hoover Institution a centre where he could continue the studies that would be his contribution to the flame of freedom and truth. I felt that this was also true for the last phase of Bert's life. He published his large work *Marxism, One Hundred Years in the Life of a Doctrine,* a careful, definitive study with much new material on such subjects as Marx's relations to the Paris Commune. Its critical acumen and scholarship were not welcome, however, to a generation that had become ecstatic over the word " alienation." Then came *The Bridge and the Abyss,* a study of the Lenin-Gorky friendship

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that illumined the psychological dualities of revolutionary intellectuals. Finally, what may be the crowning work for his many friends and future students, 41 chapters of his autobiography.

BERT Wolfe's work is placed among the highest achievements of American political thought; nonetheless, he was not an ambitious man. When he took his bachelor's degree in 1916 at the City College, the respected chairman of the Department of English, Professor Lewis Freeman Mott, offered Bert a "tutorship," and the virtual assurance of an academic career. Bert chose instead to teach at a school where the higher salary enabled him to marry his beloved Ella. He was singularly indifferent to prestige and pomp. When a friend of his was deciding whether to leave Berkeley in 1966 for a lesser university in Canada, Bert advised him to go wherever he could get the most done of what he wanted to do; everything else, Bert felt, was relatively trivial. In later years, Bert read comparatively little (he did not read Solzhenitsyn, with whom he had so much in common, until he was called upon to review *Lenin in Zurich*), for he had to husband his slender and failing physical resources. Nonetheless his spirit never flagged; he was much amused when I said he would keep on living so long as he had "unfinished business." That was true, he said.

Bert remained sceptical, however, of the prospects for Soviet-American *détente*, and no doubt he saw the new Euro-communism as an attempt to do all over again, and probably with equal futility, what he had tried to do with American "exceptionalism." A couple of years ago he and Ella happened to encounter in Mexico City the American Secretary of State, Henry Kissinger. The Mexican police became agitated when they saw this tall, thin, wan, old man, with a smiling countenance, wending his way towards Kissinger, but the Secretary of State, hearing who he was, said: "I want to meet that man. I've read every one of his books." So the Mexican police let Bert pass, and he told Henry he admired him, but that his *détente* policy was "for the birds." But no one would have been happier than Bert if for this once he had been proven wrong, and that Don Quixote might on some rare day find the dream coinciding with reality.

THE human drama of the participants in communist movements characteristically fascinated Bert. The book of collected sketches *Strange Communists I Have Known* was thus a complement to the more formalized essays collected in *An Ideology in Power*. Its title was a whimsical adaptation by Bert of the title *Wild Animals I Have Known*, a book by the Canadian naturalist, Ernest Thompson Seton. He hoped to add further chapters in political "characterology" in a later edition.

In all these personal essays, Bert preserved an almost Victorian sense of decorum. I think he was glad, for instance, that he could suggest that Inessa Armand had not been the "mistress" of Lenin, even

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though he differed on this point with other biographers. He was mindful of the unconscious, irrational motives which moved people, but it was a region which out of a sense of chivalry he preferred not to explore himself. In his second book on Diego Rivera, for example, he wondered as to the causes which could lead people who prize freedom to join a movement that would destroy it. Marx had no answer, "perhaps Freud does though: he called it the death wish," wrote Bert, but that was all he would say.

Perhaps his spirit remained so serene because there was almost nothing in Bert of the sense of guilt that characterized so many of his former comrades. When Arthur Koestler met Bert, he asked him what manner of guilt-feeling had led him to become a Communist. Bert replied that it was no guilt motive in his case, but it was in 1916–17 as an opponent of the World War that he had been led into Left Socialism. And indeed there was always a sense of moderation, of proportion, in Bert even during his Communist days. He believed in reasoning with men. When Diego Rivera clashed publicly with Nelson Rockefeller because Lenin's head was prominently placed high in his Radio City mural, Bert advised him to yield on Lenin's head, and save the rest of the large painting. Diego, however, was persuaded by others to stand uncompromising, and to trust in demonstrations by the "masses"; six months later the mural was torn from the walls. But then, as Bert noted, the Soviet bosses minced matters even less when it came to Diego's art; they looked at his sketches, and heard his talk, and then decided they wanted none of his work on any Mocow wall.

BY Bert's side throughout his life was his wife, Ella. He always carried with him a photograph of Ella in her girlhood beauty. She shared his activities, accompanied him to Moscow and Mexico, shared his San Francisco underground days. In his ailing years, she enveloped him with her love, patience, and understanding.

Listening to Ella and Bert in the evenings telling stories, and arguing affectionately over the variants, was to experience the art of story-telling as it must have been practised in Cervantes' time. One evening in a delicatessen store they narrated how the poet Vladimir Mayakovsky had stayed with them for several months in Brooklyn (the poet particularly liked Ella's mother's cheese blintzes). But when the Soviet authorities ordered him to come home he had no money with which to travel. The Wolfe family thereupon came to his rescue with their meagre savings. Back in Russia, the poet decided to cancel his debts to capitalist America; not until Bert complained of this uncomradely behaviour to the Soviet party did the poet repay them. Then by way of self-exculpation, the poet invented the story that he had spent the money to support an illegitimate child in America. Though wholly imaginary, it was duly incorporated into learned books. Then too there was the story of the love letters of Leon Trotsky to

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Frida, Rivera's wife, which Frida in her sorrows confided to Ella; when Frida asked for them to be destroyed, Ella loyally carried out her wish.

Bert, it should be mentioned, tried his hand during the melancholy thirties at a work of science fiction, whose theme was the consequence for humanity of its mastery of the secret of prolonging lifetimes indefinitely. Although the publisher's bankruptcy led to the scrapping of the book, a Spanish translation did appear in Chile in 1942 under the title of *Mundo sin muerte* (Deathless Days). Bert was also something of a gourmet. Invariably, when we dined out, there was some fine point in cookery, above my comprehension, which he wished to discuss with the bewildered chef. His laughter was spontaneous; his kindly smile was quizzical towards the strangeness of things; Diego Rivera failed to capture its meaning in the lifeless renditions of Bert on his murals. Bert was never righteous or scolding towards the later strange generations of communists. It was all part of the drama of human sapience, whether comedy or tragedy, rational or irrational, he did not know.

Perhaps nothing illustrates better the substance of Bert Wolfe's insight than these words: "We might do well to remember that the human spirit is fearfully and wonderfully made, and that . . . in things of the spirit more can be accomplished by coals of fire than by bullying."

LEWIS S. FEUER

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SURVEY Crostic No. 3 Answer

[Bertram D.] Wolfe, *Marxism*: [*One Hundred Years in the*] *Life of a Doctrine*: It was from the standpoint of their hopes for a unified Greater Germany that Marx and Engels judged the rights of all other nations. So nationalistic in tone were Engels's two pamphlets that it was widely believed that a Prussian general had written both.

A. Witte
B. Of the Just
C. League
D. First International
E. Eighth
F. MTS
G. A. N. Tolstoy
H. Rowdy
I. Xenophobia
J. Intelligent
K. Strapped
L. Might
M. Lowenthal
N. If
O. Fat and Thin
P. East
Q. Org
R. Fashoda
S. Apparat
T. Deviates
U. OSS
V. Cha
W. Theorien ueber den Mehrwert
X. Rightist
Y. Inessa Armand
Z. New World
ZZ. Engels

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SURVEY
a journal of East & West studies
published by Oxford University Press

EDITORIAL ANNOUNCEMENT

Beginning with the Winter 1977-78 issue (Vol. 23, No. 102), *Survey* will be published under the auspices of the London School of Economics and Political Science (University of London). Members of the L.S.E. Centre on International Relations and other professors from the L.S.E. are joining their colleagues who are already on the *Survey* International Advisory Board. At the same time Freedom House in New York will assist in the production of the journal, which will continue to be distributed by Oxford University Press. We are grateful to all concerned.

The first two issues of Vol. 23 (Nos. 102 and 103) will be devoted (as was No. 52 in 1954) to Soviet science and technology. In the main they are based on contributions to the Workshop on that theme which was supported by the National Science Foundation, Washington, and organized by J. R. Thomas, the Soviet Programme Director at the National Science Foundation. The opinions of the individual authors are their own and do not reflect the views of the National Science Foundation or of the U.S. government. In addition, some *samizdat* material is included in No. 103 to illustrate Soviet dissident scientists' perceptions of problems relevant to the subjects discussed.

In the future, the quarterly issues of *Survey* will continue to deal with ideas and international affairs in the overall framework of East-West relations. To new subscribers the subscription rate for Vol. 23 (1977-78) is £10 (or U.S.$20). It includes postage for the four issues. Orders should be accompanied by the correct remittance and addressed to:

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IMPORTANT NOTICE

SURVEY Volume 23, 1977-78

As subscribers will know, no issues of *Survey* were published in 1977. *Survey*, Vol. 23, will now be published in four issues during 1978 and will be called the 1977-78 volume. The sequence of volumes during the years 1976-79 will thus be:

Volume 22 1976

Volume 23 1977-78

Volume 24 1979

Subscribers who have paid for Vol. 23 will receive the four issues before the end of 1978, and subscribers to Vol. 24 will receive its issues during 1979.

Survey Magazine Ltd. have instructed their distributors, Oxford University Press, to supply Vol. 23 (1977-78) and Vol. 24 (1979) at the subscription rates already paid, and apologise for the delay in publishing the four Vol. 23 issues previously announced for 1977.

Subscribers to Vol. 23 (1977-78) who have not yet renewed for Vol. 24 (1979) and subscribers to Vol. 24 who have not yet renewed for Vol. 25 (1980) should wait for appropriate renewal invoices.

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SOME PRESS COMMENTS ON SURVEY 100/101

"Everything in the 100th issue of *Survey* is of genuine use to scholars of East-West studies, yet at the same time is of no less value and interest to the general reader. . . . The breadth of subjects and interests implied by the roll call of names on the cover provides striking and eloquent testimony to the outstanding quality of the journal before the reader even opens it. . . ."

The Times, Feb. 11 1977.

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The Sunday Telegraph, Feb. 20 1977.

"The last 22 years in East-West relations . . . are examined by Mr Leopold Labedz and some 50 leading authorities in the 100th Anniversary issue of *Survey*. It is not surprising that *Survey* being the first Western magazine to publish the writings of Sinyavsky, Amalrik, Solzhenitsyn, Sakharov and many a lesser well-known dissident under Communist rule, should reveal for the first time the fate of Ivan Maisky, Russia's wartime ambassador to Britain. . . ."

The Daily Telegraph, Feb. 11 1977.

"The Russians do not like *Survey* magazine, which has just celebrated its 100th Anniversary with a special issue, because *Survey* 'makes the reader see the bourgeois facts' according to a book called *The Ideological Diversion of Imperialism* just published in the Soviet Union."

The Economist, May 7 1977.

"Zbigniew Brzezinski, President Carter's Adviser on National Security Affairs, has provided a blueprint for East-West relations in the 100th Anniversary issue of *Survey*. . . ."

The Guardian, Feb. 14 1977.

"Some of *Survey* 100's disclosures have caused stirs in Western foreign ministries and universities. . . . The list of its contributors reads like a Who's Who of Kremlinologists. . . ."

Time Magazine, Feb. 28 1977.

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Le Monde, Feb. 5 1977.

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Il Giornale, March 3 1977.

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Avanti, Feb. 20 1977.

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